International Marine Engineering

MAY, 1909.

THE BATES ELECTRICALLY DRIVEN HYDRAULIC DREDGER.

A Bates hydraulic dredger was recently constructed by the Société J. Cockerill at their Belgian works at Liege for the Russian government. The arrangement of the engines, pumps and electric generators, as well as the cutters and cutter mechanism, is shown in Fig. 2. The dredge is constructed in two parts, forming a double dredge, or the equipment may be considered as two separate dredges working side by side. The

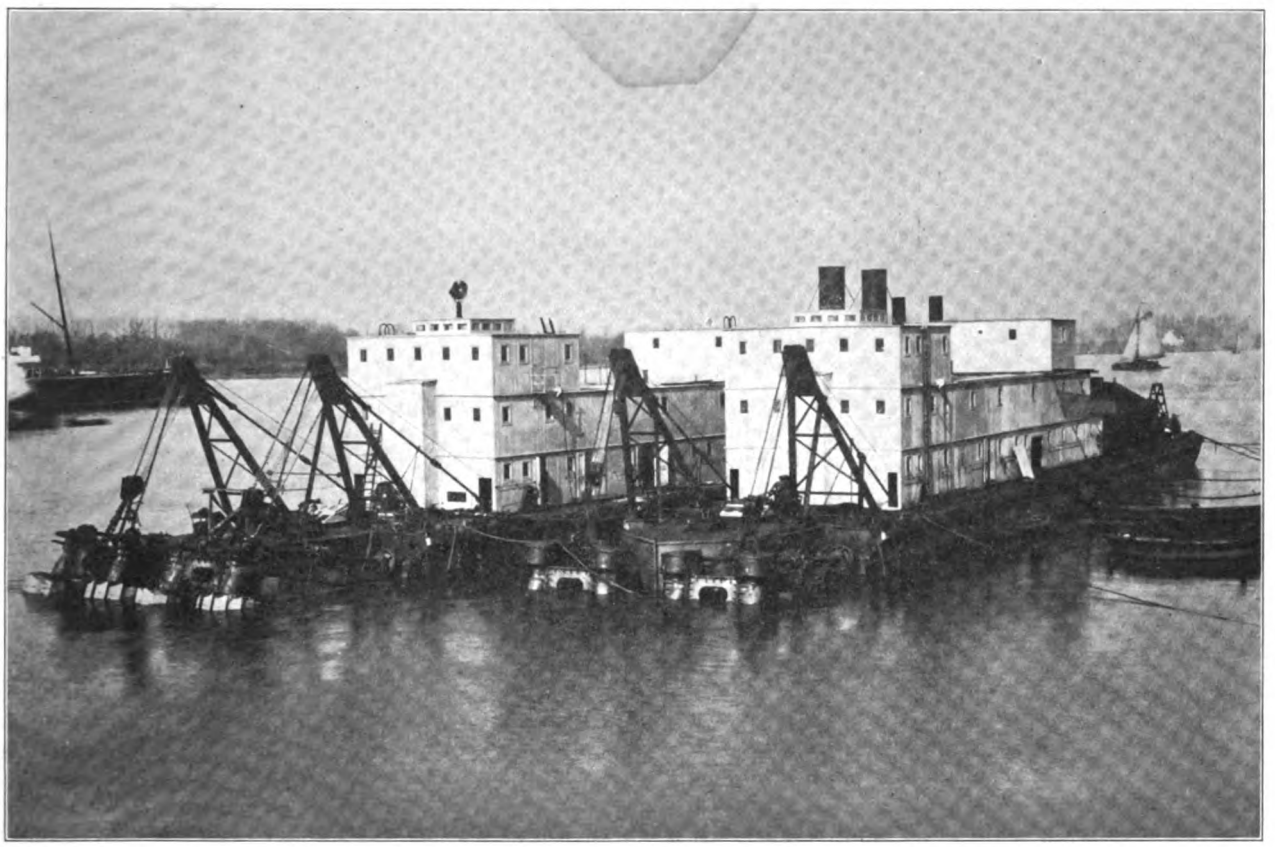

FIG. 1 —BATES DREDGERS, SHOWING LOCATION OF CUTTERS.

width was limited to the canal system Marie, through which it was necessary for her to pass on her way to the Volga from the Baltic. The double dredge, operating as a whole, makes a cut 62 feet wide at the bottom. Each half can also be operated separately when desired. Each half is 9 feet deep, 216 feet long and a trifle over 31 feet wide. The working draft is less than 5 feet.

It is interesting to note that the Volga dredge was constructed for electric propulsion and operation. Each half was equipped with an independent electrical installation consisting of a 600 kilowatt dynamo direct connected to a triple expansion engine. The current from these generators operates two bow motors of 125 horsepower each, and two stern motors, each driving a 4-foot screw propeller. The electric generators also operate two motors of 30-horsepower capacity, arranged for controlling the position of the pontoon line, although the lighting is done by a separate electric plant. The control of all the electric motors is centralized in the pilot house, where the panel switchboard, rheostat, compensators and other electric appliances are installed. There is also an electrical projector or searchlight mounted above the pilot house for night work, arranged to be controlled from below, so as to be easily directed wherever desired.

Each generator is driven by an engine of the vertical marine triple expansion type, with three cylinders working on three cranks. The stroke is 24 inches, and the high-pressure cylinder measures 14¼ inches in diameter, the intermediate cylinder 22¾ inches, and the low-pressure cylinder 37⅜ inches. Each engine develops 800 horsepower operating at a speed of 200 revolutions per minute and weighs about 25 tons.

Steam is supplied from marine boilers of the watertube type,

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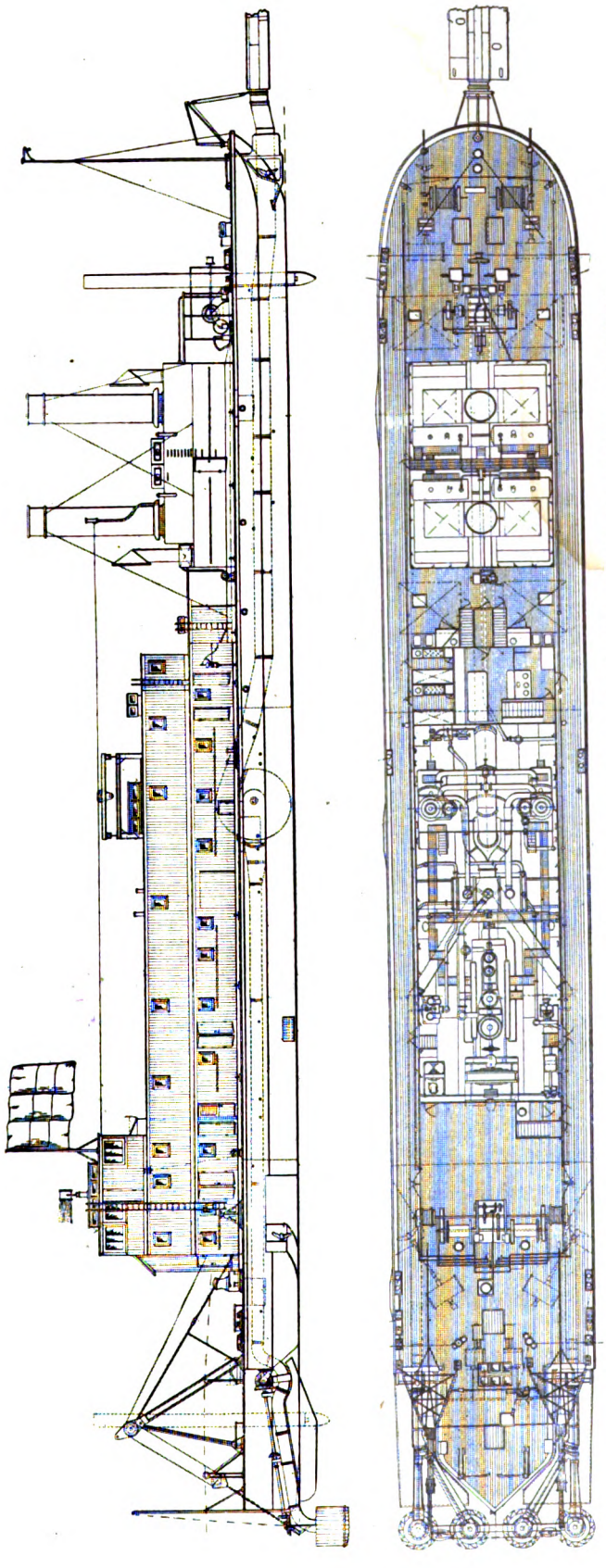

FIG. 2.—OUTBOARD PROFILE AND DECK PLAN OF BATES DREDGER, SHOWING LOCATION OF PUMPS AND PROPELLING MACHINERY.

a battery of four boilers being provided in each hull, making a total of eight, with a heating surface of 17,200 square feet.

The main centrifugal pump is driven by a divided triple expansion engine of 1,425 horsepower operating at a speed of 180 revolutions per minute. Each hull is built entirely of steel, and near the bow are recesses for the suction ladders and their bearings. The pipe pontoons are elliptical air jackets, reversible, and said not to be easily affected by currents, waves or wind. Metal joints were used, as these do not obstruct the discharge stream as much as rubber connections. There are four cutters actuated by each pair of compound cutter engines.

The propulsion of the dredge is accomplished by screws, driven by electric motors, the system adopted being three-phase alternating current. The 600-kilowatt electric generator in each hull is of the 24-pole General Electric type, operating at a pressure of 550 volts. These generators each take 800 horsepower, and at a speed of 200 revolutions per minute supply a current having a frequency of forty periods per second. The four motors of 125 horsepower each on the dredge, and the two on the end pontoon supplied with current from these generators, are of the 12-pole type, operating at a speed of 400 revolutions per minute. Each motor drives a four-bladed propeller, two at the stern and two well forward in the recesses of the hull. The two pontoon motors are of the 10-pole type, having a capacity of 30 horsepower each, and operating at a speed of 480 revolutions per minute. Each of these motors has its rotor shaft directly coupled to propeller shafts carrying three-bladed 20-inch screws.

The large motors have collector rings and external variable resistance in the armature circuit. The cooling system for this resistance is of interest. The wire is wound on an insulated copper pipe 42 feet long for each motor carried on a frame on 5-foot lengths, with fittings at the ends of the pipe. An electrically-driven rotary pump forces through this pipe 15 gallons of water per minute and in this way keeps the temperature of the resistance wire within the proper limit. A separate rheostat of this type is provided for each of the four large motors.

DESIGN OF HULLS FOR HYDRAULIC CUTTER DREDGES.

BY E. N. PERCY.

The design of hulls for sea-going dredges of both the older types and of the newer, Fruhling, system is fairly well standardized; particularly as this class of machine is built very much like a steamship; in fact many of them are converted steamships.

The hull of the cutter or inland type of dredge is open to discussion and improvement, hardly any two being alike in design and bracing, and all, so far as observed, lack some desirable feature of strength or form. Ordinary scow construction is wholly inadequate, as, besides carrying the load of machinery, etc., the hull is subject to tremendous racking strains, which should be analyzed and provided for. Furthermore, the disposition of the machinery and the construction of the ladder does not permit of scow construction. The present form of dredge is often built like a box, braced with bridge trusses; without knees, longitudinal keelsons, or other accepted methods of shipbuilding; and such construction has never failed to give trouble. Steel dredges, while stiffer, cost a great deal to maintain, are noisy, and more easily damaged by grounding or collision. Still, on account of their stiffness and compactness, there are many arguments in their favor.

To consider the various requirements of a dredge hull, one must analyze the work to be done. In the matter of draft, it

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is well, on the one hand, for them to be as shallow as possible, as many large remunerative contracts call for a machine of less than 8 feet draft; and many small contracts require less than 5 feet. On the other hand, that the dredge may be towed from place to place, and be seaworthy, it is advisable to have more draft. The breadth should be kept down to allow of contracts for narrow canals and channels, yet for seaworthiness it must be fairly large. The length seems to be about the only dimension in which there is some latitude, but this must not be extreme, because of strength, and the possibility of working around sharp corners in narrow channels.

Their general strength fore and aft is a plain problem of hull design, as is also the strength of decks, laterals, etc. Too many dredges are designed by civil engineers or bridgemen, with the result that mistakes and defects develop which would not have been made if an expert marine hull designer had handled the job. A dredge hull should be constructed along marine lines, with its own special bracing, and not like a box or a tank or a bridge, without knees, keelsons, frames, scarfed joints or other recognized methods of ship carpentry and construction. The particular points of stress to be handled very carefully are the foundations under the machinery, the thrust of the ladder, the bending moment of the ladder length, tending to shear the dredge or distort it around a longitudinal center, the twisting moment of the ladder, the strains exerted by the winding machinery, the strains around the spuds and the towing bits for towing at sea.

A pit is usually made for the pump and engine, or if the engine is belted, for the pump alone. This pit is boarded up on all sides to the water level to prevent the sinking of the dredge in case the pump bursts or leaks badly.

In regard to towing ability and seaworthiness, some note must be taken of the stability, freeboard and strength of housing. The hull should be either pointed or flared forward, and provision made for positive support of the ladder in a heavy seaway. Also, some provision should be made for draining and pumping while at sea.

The choice of materials is the first thing to decide. A steel hull costs from 30 to 40 percent more than a wooden one of the same size. It is stronger and longer lived, but requires great care and frequent docking. It has been suggested to use a composite hull with a steel frame and wooden planking or sheathing. This has never been tried except with steamships, but seems to work very well in their case.

In taking care of the various special strains, there must be provision for each, not a general heterogeneous, hit-and-miss bracing. Under the boilers, engines and pumps should run continuous stringers or keelsons. These should not be stopped at the end of the machinery space, as the hull will develop a weak point there. They should extend from stem to stern, either as part of the hull or built up on the bottom frames.

In the writer's opinion, no machinery should be on the upper deck, except light self-contained apparatus, such as tools, electric light plant, etc. Main engines or winding machinery placed there tend to distort the hull, open seams and cause vibration that would not occur if they were on heavy bedplates resting on the keelsons or frames. As the winding machinery is obliged to be on a level with the deck, the least that could be done would be to connect it rigidly to the bottom of the dredge with structural work or a bedplate, instead of putting in a few stanchions.

The thrust of the ladder is equal to twice the greatest pull exerted by the winding drums and should be distributed by girders extending from the ladder supports to all parts of the hull, taking care that it is not concentrated on any one point. These same girders should be attached to the winding gear bedplate, with ample provision for thrust fore and aft of the bedplate. The side bending moment of the ladder is a maximum when the two spuds are down, and the moment is from the point where the cable leaves the cutter sheave to go ashore to the center of either spud. It tends to distort the hull between the spuds, and has been known to split it wide open. As can be seen, the moment is large and the condition can easily occur. The lateral flexure of the hull is not an important item in ordinary designs, but the strain between the tow spuds is best taken care of by connecting them with two girders, lying in the plane of the upper and lower decks respectively, and connecting these girders to the two vertical girders extending from the foot of the ladder. The placing and bracing of towing bits is too well known to need description.

In many respects there is no reason why a dredge should not follow the lines of steamship design. Few have adequate drainage apparatus, and their hulls deteriorate accordingly. Usually a siphon or two and a pipe from some pump are the complete outfit. If the space between frames cannot be drained, it should be filled up with wood or cement, and a regular drain pump sucking from carefully built sumps put in. The frames often decay first, because of being alternately wet and dry. As the ladder and headframe are very heavy, also the end of the hull containing the cutting and winding gear, lever house and suction pipe, the displacement is considerable, and to maintain trim, two branches or extensions of the hull run out alongside the ladder.

The ladder consists of two heavy I-beams, connected by saddle plates. Under the plates is the suction pipe. Above it the shaft to the cutter. The construction is tapering. At the end is the cutter and suction head. At the upper end are the trunnions in which the ladder sits. Usually the suction pipe turns in through the center of this trunnion, revolving with the ladder in a stuffing box; but some makers, particularly for small dredges, use a ball joint or flexible piece of hose leading in a straight line to the pump. Through the center of the other trunnion comes the drive shaft from the cutter engine. Many dredges place the cutter engines directly on the ladder, connecting pipes with ball joints. It is open to discussion as to which is the best method. The ladder is supported by a tackle, sheaves being at two or three points on the ladder to reduce flexure and keep the cutter shaft in line.

The frame over the ladder for lifting it, and the method by which its strains are distributed to the hull, is an important hull detail. In small dredges it may be a simple A-frame or shear. In larger ones, with a long heavy ladder, and hoisting sheaves at two, three or four points, it assumes some of the complications of structural engineering. Usually the frame rests on the fore-and-aft girders, and should have considerable bearing area, as the ladder at one end, boilers at the other, and the upward component of buoyancy act on the dredge with a definite bending moment to produce flexure.

Few lever rooms are designed correctly. The levers should be self-contained, whether connected or not. The throttle of the cutter and winder should be placed so it can be used while watching the cutter board. The windows should be very low, not higher than 2 feet from the floor, so the operator can stand well back and still see the ladder. Instead of a gong, the best dredgers now have regular telegraph to the engine room, and telephone connection with the pipe-line crew. Instruments for sighting are provided, showing instantly the angle of swing and width in feet. Several instruments showing the position of the cutter have been invented, but are not, as yet, very reliable. The lever room should have windows on all sides, as the operator should be able to see, not only his ladder, but the spuds, the pipe line, the bank, approaching craft, the weather, and anything else tending to keep him properly informed.

Many dredges still provide quarters for the crew on board, but it is a poor place to live, on account of the noise and dirt,

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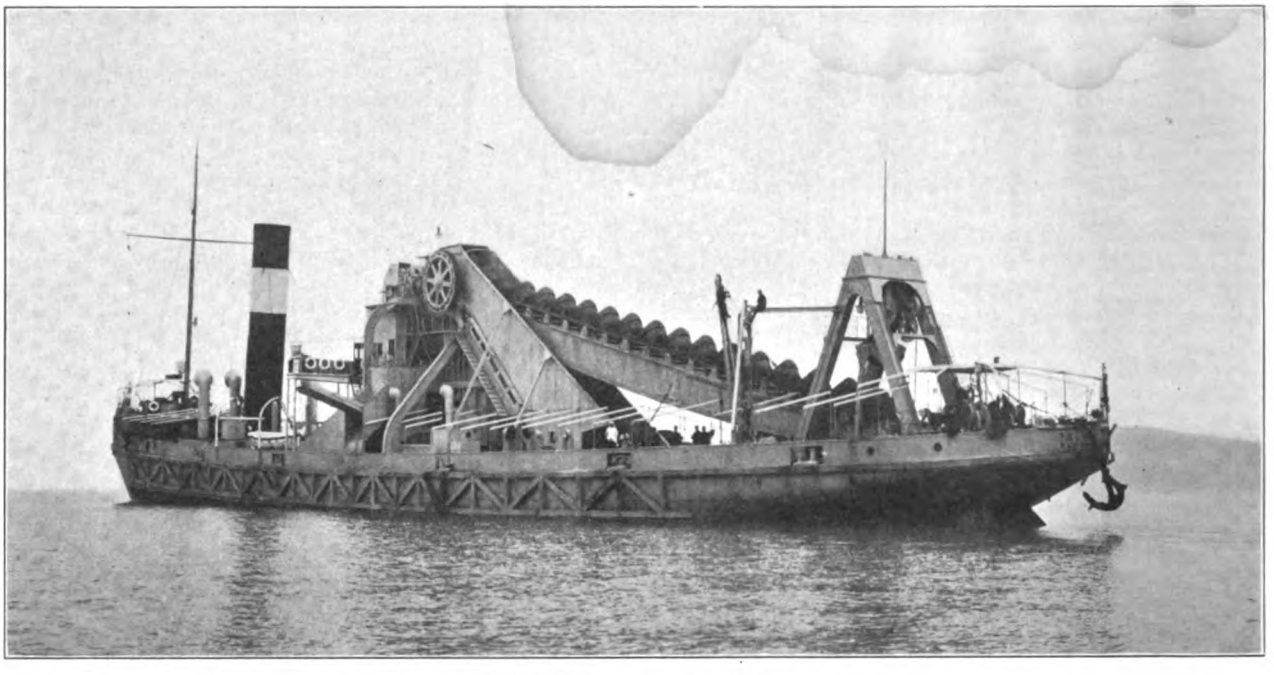
and most firms now use a separate boat to house the men. Among the details to be provided for, or at least considered, are boarding ladders, fire protection, boat davits, chocks and bits for scows, tugs, etc., coal and ventilation hatches, ladders and gratings. It is becoming customary to provide an auxiliary engine room for all auxiliaries, instead of distributing them all over the dredge. This includes feed pumps, air pumps, circulating pumps, bilge pumps, water-service pumps, dynamo engine, cutter engine and oil pumps. The winder engine, of necessity, is on deck. Provision must also be made for electric wiring, as electric lights, and in some cases electric auxiliaries, are becoming a greater necessity every day. Searchlights and arc lamps are used on the more advanced designs. Incandescent lights are used on small dredges, but are inadequate, as a rule, because they are so irregularly operated. Tanks for fresh water, feed water, wash water, oil, waste and grease must be provided. Painting specifications should be as carefully written as for a steamship hull.

AN EIGHT-YARD DIPPER DREDGE FOR THE CUBAN GOVERNMENT.

A large dipper dredge, which involves some novel features, was built by the American Locomotive Company for the Cuban government and delivered in the harbor of Havana in December, 1907. The dredge was built and erected complete and in working order (with the exception of the deckhouse) in the James River, at Richmond, Va., and tested under steam. Upon the conclusion of the test the A-frame, boom, spuds, etc., and all external parts were dismounted and securely stowed on board, and the dredge made ready for sea. It was then towed to Havana without mishap, and the external parts re-erected.

The hull is of steel 125 feet long with a beam of 42 feet and a depth of 12 feet at the bow. It is built in a very substantial manner, and stiffened internally with two longitudinal steel trusses, which do not, however, extend above the level of the deck. The truss is built into the hull in such a way that the steel deck forms part of the strength of the top chord



THE PELUSE, LARGEST SEAGOING BUCKET DREDGE AFLOAT.

THE BUCKET DREDGE PELUSE.

What is said to be the largest bucket dredge afloat has recently been delivered by Lobnitz & Company, Ltd., of Renfrew, to the Suez Canal Company, Port Said. The *Peluse* is a twin-screw, seagoing dredge, 305 feet long over all, with a molded breadth of 47 feet and a molded depth of 20 feet 2 inches. The hull is amply sub-divided by watertight bulkheads to render her practically unsinkable in case of collision. The vessel is classed by the Bureau Veritas in their highest class. A steel deck, sheathed with teak, is fitted throughout, and there is a raised forecastle at the bow and raised poop at the stern.

The main propelling engines have a total indicated horsepower of 1,800, and the separate dredging engine 600. The latter is of the three-crank design, placed on the main framing. Steam is furnished by three Scotch boilers, each 15 feet diameter and 10 feet 7½ inches long. Hydraulic power is used for all the auxiliary machinery and Lobnitz patent hopper door arrangements are fitted. A separate condensing plant is fitted for all the machinery. The dredging depth of the vessel is between the limits of 20 and 50 feet below the water level.

of the truss, and, in fact, all the strength of the hull is in its main body, no headframe or other superstructure being used for the support of any of the working parts.

The boom is of steel, 44 feet long and of massive construction. It is of the Robinson patent type, having a straight taper and a steel turntable, built solidly with the base of the boom. This type of boom has now been in service on several dredges for a number of years, and it is claimed has given good satisfaction. It has the advantage of simplicity and strength, while the swinging power is applied in the most effective way.

The hoisting machinery consists of a main engine, having cylinders 17 inches by 20 inches, double geared to a conical drum. The main hoisting is on the parallel system. The two ends of the single length of rope are attached to the opposite ends of the drum in such a way that the fastenings are readily accessible, while the middle of the rope is equalized around a thimble at the dipper. In this way each of the two parallel parts of the rope bears half of the load at all times. The main sheaves are of cast steel, 8 feet diameter with double grooves. This method of hoisting is a great improvement over the earlier type of direct wire rope hoist in which a

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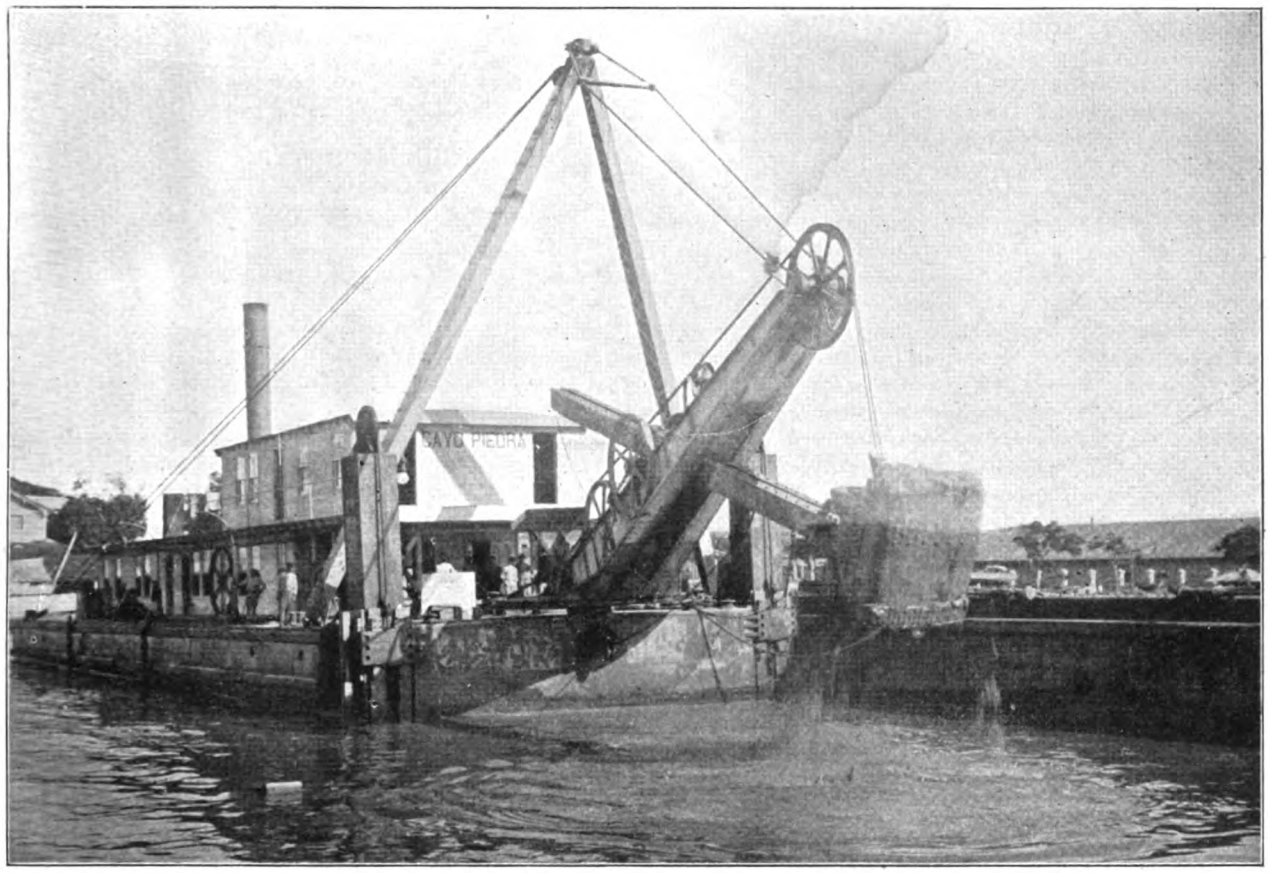
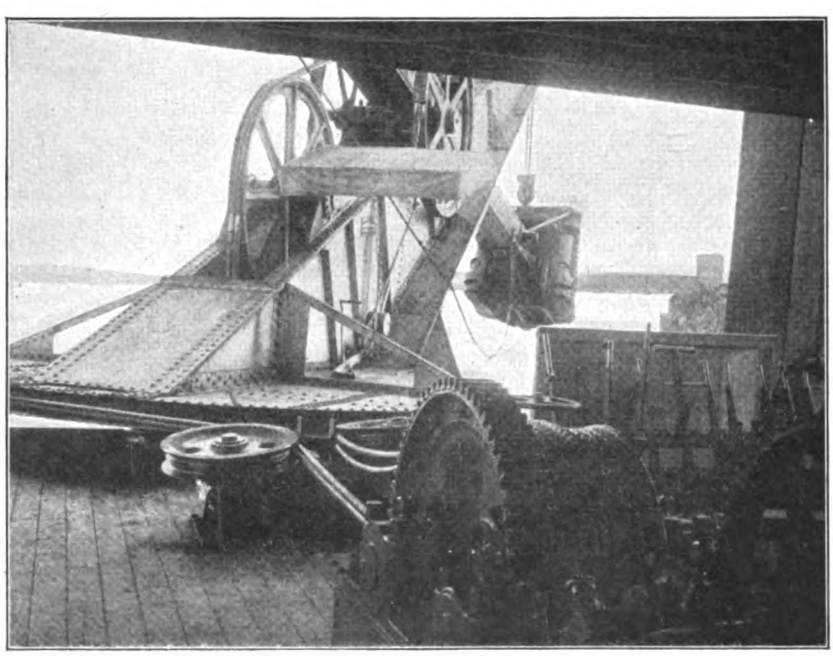


TYPE OF DREDGE BUILT BY THE AMERICAN LOCOMOTIVE COMPANY FOR THE CUBAN GOVERNMENT.

single rope of large size is used. Wire rope for hoisting on dipper dredges has now practically entirely superseded chain on account of its smoothness of working and efficiency, and also because it does not break without warning, as is the case with chain.

The first dredge of considerable size having a direct-wire rope hoist was built in 1890 from Mr. Robinson's designs, and has since been largely used. The use of the single-wire rope is, however, attended with the disadvantage of lack of durability, as the life of such ropes is usually not more than four to eight weeks. Even with such short life, however, the rope is preferred to chain, and under the improved system here adopted the full advantage of the rope is retained, while the durability is greatly extended. The length of life of the ropes



LADDER AND DIPPER OF 8-YARD DREDGE.

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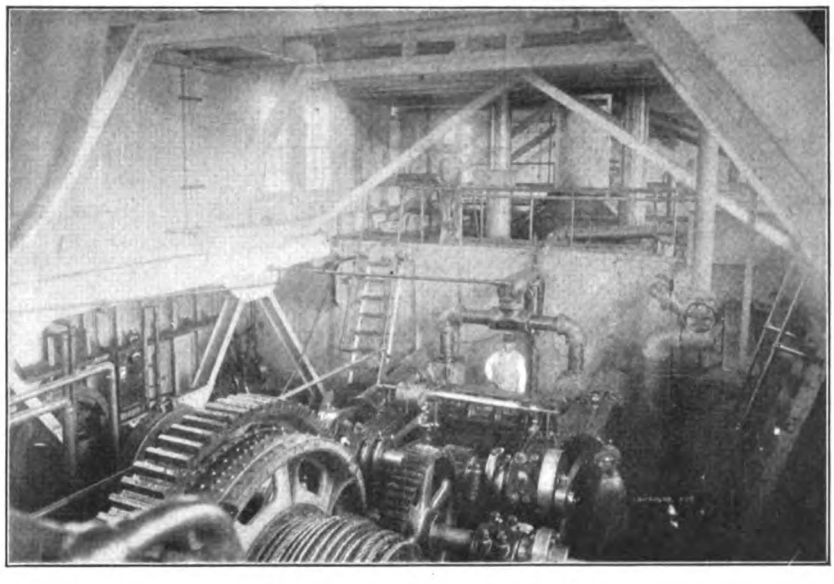
under this new system has not yet been determined, as the dredges have not been in service a sufficient length of time to require renewal. It is known, however, that under this system the ropes, when of proper quality and with machinery of proper design, will last at least a year.

The next important improvement which has been made is in the spuds. These are of steel, 40 inches by 40 inches, and are of special design. Many experiments have been made with steel spuds, but up to the present time they have proved less satisfactory than wooden spuds, owing to their lack of elasticity and to the difficulty of withstanding the enormous concentrated stresses in the riveted members. When the dipper dredge is working in fairly deep water, the stresses on the spuds are very severe and concentrated at the point of support, so that it has been practically impossible to avoid shearing of the rivets or buckling of the members. This is especially the case where steel spuds are used in connection with a steel hull. Recognizing the necessity for elasticity of connection and the distribution of the stresses over a sufficient length of spud, a simple system of cushion supports has been adopted which has proved to be very successful in service.



MACHINERY SPACE OF THE CUBAN DREDGE.

The swinging engines are located on the main deck, with rope leading directly to the turntable, and have 9-inch by 9-inch cylinders double geared. These engines, with the proper ratio of gearing, give ample swinging power under all conditions.

The boiler is of Scotch marine type, 11 feet 6 inches diameter by 11 feet long, and furnishes ample steam for the dredge with natural draft. The dredge is fitted with all usual auxiliaries, including surface condensation, electric light, hand and steam capstans, as well as commodious crew's quarters. Special attention has been paid to ease of operation, so that the full work of the dredge can be maintained in the warm climate without fatigue to the operator. With this end in view all the important motions are operated by steam, and the dredge, as a whole, including the spuds, is under the direct control of the engineer.

The dredge is named the *Cayo Piedra*, and was furnished by the Atlantic Equipment Company, of 30 Church street, New York, to the order of Mr. Lombillo Clark, of Havana, Cuba, for the Department of Public Works. The dredge was designed by A. W. Robinson, M. Am. Soc. C. E., and built under the supervision of Mr. José Primelles, engineer for the purchasers.

MONSTER BATTLESHIPS.

BY SIDNEY GRAVES KOON, M. M. E.

When England set the pace, in 1905, with the now classic *Dreadnought* of 17,900 tons, the leading naval powers were building battleships of 16,000 to 16,600 tons displacement as a maximum. Sizes had very gradually advanced to that figure from the 14,150 tons of the *Royal Sovereign* class, built under the (British) Naval Defense Act of 1888. In the first four years of the *Dreadnought* era, however, such has been the impetus given design by that famous ship that displacements have advanced to 19,000 tons in the Italian *Mirabello* and German *Ersatz Beowulf;* 19,250 tons in the Brazilian *Minas Geraes;* 20,000 tons in the American *North Dakota;* 20,250 tons in the British *Neptune;* 20,750 tons in the Japanese *Huki* and Russian *Peter Veliki;* and now a bill has been passed by the United States Congress providing for the construction of two vessels of 26,000 tons each, at an estimated finished cost per vessel of $9,500,000—no more than the estimate of two years ago for the 20,000-ton *North Dakota*. Very little information is available concerning the design forming the basis of this bill, beyond the fact that it calls for a sea speed of 20½ knots, and a main battery of eight 14-inch guns,* presumably mounted in pairs in four turrets on the center line, as with the 12-inch guns on the 16,000-ton battleship *Michigan*.

If we assume that the *Michigan* has been taken as a basis of departure, and the whole vessel expanded, as have been the main battery guns, in the ratio of the cube of 14/12, we find a marked resemblance between the figures for the new vessel and those for the expanded older ship. Thus, this ratio of 343/216, applied to the displacement of the *Michigan*, gives 25,407 tons, or only slightly less than the displacement of the new design. Let us examine a table of weights based on those of our type ship:

* One account says twelve 12-inch 50-caliber guns, mounted in pairs in six turrets on the center line, all bearing on either broadside.

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	Michigan.	*A.*	*B.*
Hull and fittings (*a*)	7,469	11,860	12,140
Equipment and 2/3 stores (*b*)	823	1,307	1,250
Machinery and water	1,643	2,609	2,250
Normal coal supply	900	1,429	1,400
Battery and 2/3 ammunition	1,118	1,775	2,460
Armor and backing	4,047	6,427	6,500
Displacement	16,000	25,407	26,000

(*a*) Includes protective deck. (*b*) Includes officers, crew and effects.

The figures in the first colum represent, in tons, the weights of the principal component parts of the displacement of the *Michigan*. The second column shows the same figures expanded in our ratio of 343/216; while the third is obtained from the second, as will be explained.

The *Michigan*, with 16,500 indicated horsepower, is expected to develop a speed of 18.5 knots. This accounts for an

$$\text{Admiralty coefficient } \left(\frac{(\text{displacement})^{2/3} \times (\text{speed})^3}{\text{horsepower}} \right)$$

of 244. With a hull exactly like that of the *Michigan*, except for size, the ship *A*, with 26,200 horsepower—the same power per ton of displacement—(as accounted for by the same proportionate weight of machinery) should show a speed of 19.5 knots. For the speed to reach 20.5 knots the horsepower would require to be increased to 30,500. But with the larger hull would come increased relative ease of driving at high speed; and if, as must certainly be the case (as explained later), the relation between length and beam be largely increased, a still further small reduction in horsepower required might be expected. Hence it is safe to assume that 30,000 indicated horsepower, or its equivalent (say, 28,000 shaft horsepower, delivered by turbines), would drive the 26,000-ton vessel at a sea speed of 20½ knots. This would call for an Admiralty coefficient, based on shaft horsepower, of 270, as compared with 273 for the *North Dakota* with 25,000 shaft horsepower and 21 knots. The turbine machinery of the *North Dakota* weighs 1,923 tons; on the same basis, turbine machinery of 28,000 shaft horsepower would weigh 2,154 tons. Allowing 96 tons reserve feed water (the *North Dakota* and *Michigan* carry only 66 tons), our machinery and water figures out 2,250 tons, as shown under ship *B*. This great reduction in machinery weight is due to the use of the steam turbine.

The equivalent indicated horsepower of *B* at 18.5 knots—the speed of the *Michigan*—would be 22,000. For this speed, 1,200 tons of coal in the new ship would provide for the same steaming radius as the 900 tons which the *Michigan* carries on normal displacement. It is advisable, however, to increase this figure to 1,400 tons, as shown in the table, giving a radius abut 17 percent in excess of that of the *Michigan*—always assuming that the power is obtained on an equivalent expenditure of fuel per horsepower per hour.

The crew of a large ship is smaller in proportion to the size of the ship than is that of a smaller ship. This fact, affecting a number of items under the general heading of equipment and stores, would permit a reduction of that figure to 1,250 tons; which ought to permit the carrying of nearly or quite a full supply of stores.

The *Michigan* has a secondary (anti-torpedo-boat) battery of twenty-two 3-inch guns. The expanded ship *A* would allow for twenty-two 3.5-inch guns. These are too light for effective work at the range of the latest and most powerful torpedoes. Six-inch guns should be used (the *North Dakota* carries fourteen 5-inch guns); and it is by no means certain that 7-inch guns would not be more satisfactory. Both the 6-inch and 7-inch weapons are very handy, rapid of fire and sufficiently powerful for the work; but the 7-inch would have a decided advantage in attacking light armor at battle ranges. A battery of twenty 7-inch guns could be provided, with 200 rounds of ammunition per gun, on a weight of 860 tons for guns, mounts and ammunition; while the 3.5-inch guns which they replace would weigh 175 tons. This accounts for an addition of 685 tons to battery weights, bringing the figure up to 2,460 tons. If we decide on a secondary battery of 6-inch guns, we find that thirty-two may be installed on the weight of the twenty 7-inch guns. This would furnish an enormous volume of anti-topedo-boat fire.

WEIGHT OF BROADSIDE IN POUNDS.

	Main.	*Secondary.*	*Total.*	*Per Ton.*
Ship *B*, 7-inch guns	11,200	1,980	13,180	0.507
Ship *B*, 6-inch guns	11,200	1,890	13,090	0.503
Ship *A*	11,200	296	11,496	0.452
North Dakota	8,700	420	9,120	0.456
Michigan	6,960	154	7,114	0.445
Connecticut	3,480	2,156	5,636	0.352
Dreadnought	6,800	192	6,992	0.391

The various changes which we have made in passing from ship *A* to ship *B* have resulted in a slight increase in the weight available for armor—no more than would be necessitated for additional hull armor to cover in equal proportion the side of the larger ship—leaving the schedule of thickness the same for *B* as for *A*. But it should be noted that, on our original assumption of an expansion in the linear ratio of 14 to 12 from the design of the *Michigan*, this expansion, if we cover the same proportionate area of the side of the ship, will affect the thickness in that same ratio. Thus, the main belt armor may be made 14 inches thick, maximum, in place of 12 inches; the upper belt 11 2/3 inches in place of 10 inches; the barbette armor 11 2/3 inches in place of 10 inches; the turret armor 14 inches in place of 12 inches front, and 9 1/3 inches in place of 8 inches rear; and the deck armor 3½ inches in place of 3 inches. It is probable that, in developing the design, slight reductions would be made in some, if not all, of these figures, with corresponding extension of the area covered by the armor protection.

By accepting the same schedule of thickness as on the *Michigan*, and covering the same proportionate areas, we find that the requirements for armor would be $4{,}047 \times (^{14}/_{12})^2 = 5{,}509$ tons only, in place of 6,427 tons. Making some allowance for the increased proportionate length of the new ship, as compared with the *Michigan*, the figure may be tentatively set at 5,700 tons. This leaves 727 tons for additional armor, or additional battery, or increased fuel supply, with consequently augmented steaming radius, or greater engine power, with correspondingly increased speed.

The armor schedule could be increased in thickness an average of 12½ percent, or correspondingly increased in area covered, or both could be increased 6 percent.

Or, as a pair of 8-inch guns, with mounts, turret, armor and ammunition calls for about 180 tons, eight such guns, in four turrets, could be provided.

Or the steaming radius could be increased 50 percent.

Or the shaft horsepower could be increased by 11,000, involving a probable increase in speed from 20½ knots to 22½ or 23 knots.

As to dimensions, those of the *Michigan* are 450 feet length on waterline, 80 feet molded beam, and 24 feet 6 inches mean draft at her normal displacement of 16,000 tons. Our expanded ship would have a length of 525 feet, a beam of 93 feet 4 inches, and a mean normal draft of 28 feet 7 inches. Her block coefficient would be the same (0.635) as that of the *Michigan*. But a beam of 93 feet and more would bar the ship from almost every drydock in the world. Even 90 feet beam would have this effect, in only slightly lesser degree. If we fix the beam at 88 feet, as in the *Lusitania*, the results are

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somewhat better. With the same draft and block coefficient as before, this calls for a length of 557 feet. Such an increase in length would require small additions to structural weight of hull. These additions might be partially reduced by increasing the depth of hull (and draft of ship), thus making a potentially stronger girder. In order to do this without adding displacement, the lines could be made finer, and this would have the added beneficial result of aiding propulsion. The *Michigan* was benefited by this "fining" of the lines, as compared with the earlier *Connecticut,* of the same size and power; the speed being increased ½ knot by the process. With a length of 560 feet, beam of 88 feet, and draft of 30 feet, the block coefficient would be 0.616, as compared with 0.661 for the *Connecticut,* 0.635 for the *Michigan,* and 0.598 for the 21-knot *North Dakota.* Exception will be taken to a draft of 30 feet, because of the shallowness of many of our harbors, but with a ship of such size it cannot well be avoided. This draft is exceeded by a few foreign warships, and by many of the largest trans-Atlantic liners.

The matter has been gone into thus in detail, partly to indicate the character of the general problem before the designer of such a ship, and partly to show what enormous power can be concentrated in such a large ship, and how mere size is in itself a most valuable asset.

THE LOBNITZ PATENT ROCK BREAKER.

Subaqueous excavation of rock is usually accomplished in one of two ways, either by the use of explosives or by some form of rock breaker, operated from a dredge or float. The use of explosives usually leaves the broken rock in large pieces, which are difficult to remove by the ordinary methods of dredging. Mechanical rock breakers, on the other hand, tend to pulverize the rock or break it into smaller pieces of uniform size, which can be handled by a dredger as easily as mud, silt, or sand.

In the Lobnitz patent rock breaker the work is done by means of a heavy chisel, which is allowed to fall freely by its own weight on to the rock. As the whole force of the blow is concentrated on a very small surface, the tempered point of the rock cutter easily crushes the hardest kind of rock. The general arrangement of this rock breaker is shown in the photographs. The chisel is of pressed steel, weighing usually from 10 to 15 tons, and it is fitted with a hard-cutting point, called the cutter, by means of which the rock is broken. With a drop of from 6 to 10 feet, the cutter breaks its way into the surface of the rock, partly pulverizing it and partly breaking it. The cutter delivers blows on the same spot until it has penetrated about 3 feet into the rock. If the thickness of rock to be broken is more than 3 feet, it is customary to break it in horizontal layers, each about 3 feet thick. As soon as one layer is broken, the loose material is removed by means of a dredger before breaking up the next layer. After the cutter has been dropped on the same spot until the desired penetration is obtained, the barge on which the cutter is

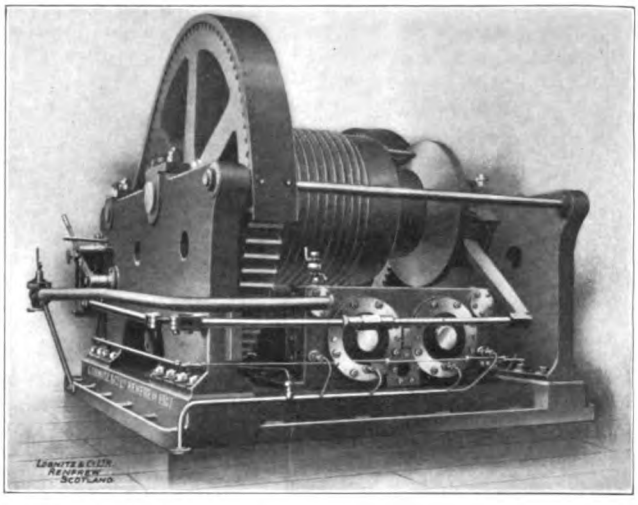

FIG. 2.—HOISTING WINCH, USED ON LOBNITZ ROCK BREAKER.

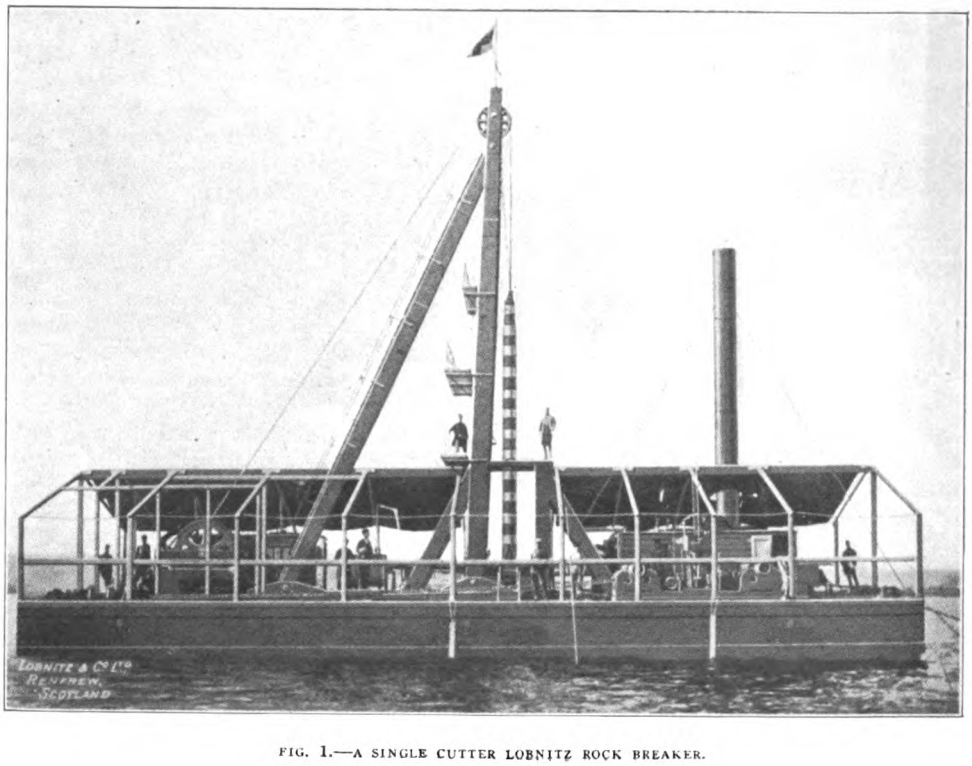

FIG. 1.—A SINGLE CUTTER LOBNITZ ROCK BREAKER.

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mounted is moved a distance of about 3 feet. This is done by means of six maneuvring chains or wire ropes, which are worked by a special steam winch, designed to insure accuracy of maneuvring. The number of blows needed to penetrate the rock to the desired depth, and the distance through which it is necessary to move the barge between the spots where the blows are struck, varies with the kind of rock which is being broken; these details being settled by experience. From ten to twenty blows are usually required on each spot to penetrate a layer 3 feet deep.

The hoisting winch, shown in Fig. 2, is a powerful steam engine with suitable gearing and special fittings for continuous running. About 1,500 blows per day of 10 hours are given in regular work. The winch is so arranged that with a lubricated steel friction clutch and automatic gear, the wire rope follows the fall of the cutter and raises the cutter again immediately after the blow has been struck. A feed pump is worked from the winch, which feeds the boiler in proportion to the amount of steam used. The feed water is preferably fresh water taken from a tank on the barge, although, of course, sea water may be used, provided the fireman understands the operation of a marine boiler with salt water. A feed-water heater, heated by the exhaust steam, is also provided.

The cutting points of the chisels are removable, so that a point best adapted for the quality of rock to be cut can be used. The points are made harder in the center than on the outside, and they remain automatically sharp if the rock is of an abrasive nature, such as sandstone. Steel similar to that used for armor-piercing projectiles is the material used for the points. When removing a cutter point from the chisel, the cutter is hoisted to a suitable height above the deck; logs are laid over the well and the screws are taken out of the end of the cutter. The end of the cutter just above the hoop is then given a sharp heat by means of two portable, pressure oil lamps. Wedges are then driven between the hoop and the point in spaces provided for this purpose, and the point is forced out. The hoop, which is still hot, is then easily knocked off by hammering around the projecting edge. A new hoop, heated to a red heat, is then shrunk on the end of the chisel, and while the cutter is still hot, it is lowered on to the new point, the shank of which has been previously greased. The weight of the cutter is sufficient to press the point home. The screws are then carefully greased and replaced, the whole operation of changing points taking from 2 to 3 hours.

These rock breakers are built in sizes having cutters weighing from 6 tons upward, capable of working at any depth and in rock of any kind. The apparatus can be made self-propelling if desired. The expense per cubic yard of average rock broken, ready for convenient dredging, may be estimated approximately by the following rule: A single cutter machine will break up per day in average rock 100 cubic yards for 1 ton of coal and the wages of four men. The cost of oil, stores and repairs, it is claimed, does not exceed the outlay for coal and wages. An average performance for one of these breakers working in hard rock is 2 cubic feet of rock broken per blow, and an average of 150 blows can be delivered per hour, making the capacity of the machine 10 cubic yards per working hour for a single-cutter machine. The machines are also made with double cutters, and the capacity is then about one-half more than with a single cutter. A crew of four men is required on single cutters, and six men on a barge with two cutters. The average coal consumption for a working day of 10 hours for a single 10-ton cutter is 1 ton, and for a two-cutter machine 1½ tons. The consumption of fresh water is estimated as about five times the weight of the coal used.

VIEW OF DREDGING OPERATIONS AT KASHMIR, IN THE HIMALAYA MOUNTAINS.

A DREDGING EQUIPMENT IN THE HIMALAYA MOUNTAINS.

An interesting dredging plant, designed by the Bucyrus Company, South Milwaukee, Wis., is now operating in the Vale of Kashmir, a British principality in the Himalaya Mountains in India. To transport this machinery to its destination, it was necessary to haul it in bullock carts for 200 miles, from Rawalpindi to Baramula. A range of mountains

TOP OF LADDER FOR SUCTION DREDGE, SHOWING CONNECTIONS TO REVOLVING CUTTER.

8,000 feet in height had to be crossed, and it was necessary to so design the dredges that no piece when ready for shipment should weigh over 3 tons. The plant consists of two 18-inch hydraulic dredges, two clam-shell derricks, and one 4-yard dipper dredge. This machinery is electrically driven by motors of the three-phase type, the electrical equipment aggregating

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2,018 horsepower, being furnished by the General Electric Company, Schenectady, N. Y.

The hydraulic dredges are designed to dig to a maximum depth of 25 feet, and to discharge the material at a velocity of 12 feet per second through 450 feet of 18-inch pipe to a maximum height of 20 feet above the water level. The 18-inch pump is especially designed for dredging. The shell and runner are steel castings, and the former has five curved arms and is cast in one piece. The pump is driven by a 350-horsepower motor, to which it is direct connected. The suction ladder carries a revolving cutter head, driven through shaft and gearing from the top of the ladder by a 100-horsepower motor. The cutter head is supplied with curved blades for properly disintegrating the material. The bow winch is driven by a 45-horsepower motor, and consists of two drums for the swinging line and one for hoisting the suction pipe. The stern winch is driven by a 30-horsepower motor and has three drums, two for raising and lowering the spuds and one for the thrust of the walking spud.

The dipper dredge is designed to dig to a depth of 22 feet below the water level. The dipper has a capacity of four cubic yards. The boom is 40 feet long and is of wood. As on the ordinary type of harbor dredges, the hoisting machinery is single-part wire rope. The pinions, gears and drums on both hoisting and swinging machinery are steel castings. The wooden boom is stepped into a cast steel pivot bearing, formed with sockets to receive the boom foot. This pivot rotates on a steel baseplate, separately bolted to the hull. The swinging circle is of structural steel and wood, 18 feet in diameter, mounted on top of the hull. The connection to the boom is made by means of arms extending out over the circle, one on each side of the boom, the center being a heavy steel casting riveted to the circle. The dipper handle is of the combination wood and steel type, with cast steel racks. The spuds are of wood, 36 inches square and 40 feet long. They are fitted with cast steel blade points. The spud drum is operated by a shaft driven from the main hoisting machinery. The stern spud is of wood, 24 inches square and 40 feet long. This spud is so arranged that it can be forced down to a position where it assists the forward spud in holding the dredge while the bucket is digging. It can also be used as a walking spud to move the boat forward when ready to make a fresh cut.

The function of the clam-shell derricks is to unload the material excavated by the dipper dredge from scows and deposit it into the spoil area at a considerable distance from the bank of the river. They are equipped with 80-foot booms, and handle a three-yard clam-shell bucket, which is of the smooth-edge type without teeth and weighs about 7,000 pounds. The derrick is built of wood and is arranged to travel on tracks, the boom mast and swinging circle being supported on ten wheels, running on a two-rail track, the hoisting and swinging machinery being carried on six wheels on the same track. The back leg is anchored on a timber frame, running on four wheels on a single track, parallel to the main track under the hoist and about 45 feet distant from it.

On account of the great distance from the place of manufacture, the machinery was made especially heavy, all gears, drums, pinions and fittings being made of steel castings, which weigh considerably more than those put into dredges of the same size in the United States. The plant has now been in successful operation for about six months, and no defects have been reported.

The programme for the reconstruction of the Spanish navy involves the building of three heavy-armored vessels of about 15,000 tons displacement; three 350-ton destroyers, or three submarines, and twenty-four torpedo boats.

AN AMERICAN TRAMP STEAMER.

A steel freight steamship is being built by the Newport News Shipbuilding & Dry Dock Company for the A. H. Bull Steamship Company, which has the following principal dimensions:

Length over all	329 feet.
Length from aft side of stem to fore side of rudder post	317 feet.
Beam molded	46 feet.
Depth molded	24 feet 3 ins.
Load draft	20 feet.
Deadweight carried on above draft, about	4,600 tons.

As indicated on the accompanying general arrangement plan, the vessel has a single deck, a raised forecastle, long bridge, short, full poop, and is schooner rigged with two pole masts. There are two separate steel deck houses on the bridge deck, a steel pilot house on top of the forward deck house, and a flying bridge at the level of the top of the pilot house. The machinery is located amidships; the two main boilers arranged with an athwartship stokehold forward, and a screen bulkhead dividing the boiler and engine rooms. Side bunkers are fitted abreast the boilers and at the sides of the engine room, the bunkers being filled by a coal chute, located between the boiler and engine casings, with its hatch at the level of the top of the deck house. Additional coaling facilities are provided through small hatches in the bridge and upper decks directly over the boiler-room bunkers.

The vessel is divided into compartments by five watertight bulkheads, all extending to the upper deck. These are located at the fore peak, in the middle of the forward hold, forward of the boiler room, aft of the engine room, and at the after peak respectively. The after hold is divided into compartments by a portable wooden bulkhead, and a similar bulkhead is located near the after end of No. 2 hold to provide a reserve bunker, forward of the boiler room. The cargo holds are further subdivided by a centerline bulkhead extending from the tank top to the upper deck. This bulkhead is of steel between the hatches, and in way of the hatches is of wood, made portable. There is one large hatch to each of the cargo holds; all hatches having coamings 3 feet 6 inches high. The space under the bridge deck, with the exception of that devoted to machinery casings, is used entirely for cargo, as is also the space under the poop. Portable wooden shifting boards are fitted at the centerline under the bridge deck, extending from the boiler casing to the forward end. The total cargo space is 244,000 cubic feet for bales, and 263,000 cubic feet for grain.

Accommodations for the officers and crew are provided in the two deck houses and under the forecastle deck. The forward deck house contains staterooms for the captain and deck officers, a bath room, officers' mess, pantry and storeroom. The after deck house contains staterooms for the engineers and cooks, a bath room, mess room and pantry. Under the forecastle two staterooms are provided for quartermasters, the carpenter and boatswain; also quarters for six seamen and ten firemen. The galley is located in a separate steel enclosure forward of the boiler casing. The pilot house is provided with a separate chart room, which is also arranged for use as a stateroom. In the captain's quarters the finish is oak; in the other quarters it is cypress.

The general type of construction is indicated on the midship section. The vessel is being built under Lloyd's spar deck rules, with one deck and a tier of wide-spaced hold beams, with a wide stringer fitted on the latter. There is a double bottom throughout, with solid floors on every frame, and two intercostal longitudinals on each side of the vertical keel. Double frames and additional longitudinals are fitted at the forward end. This construction of double bottom was adopted

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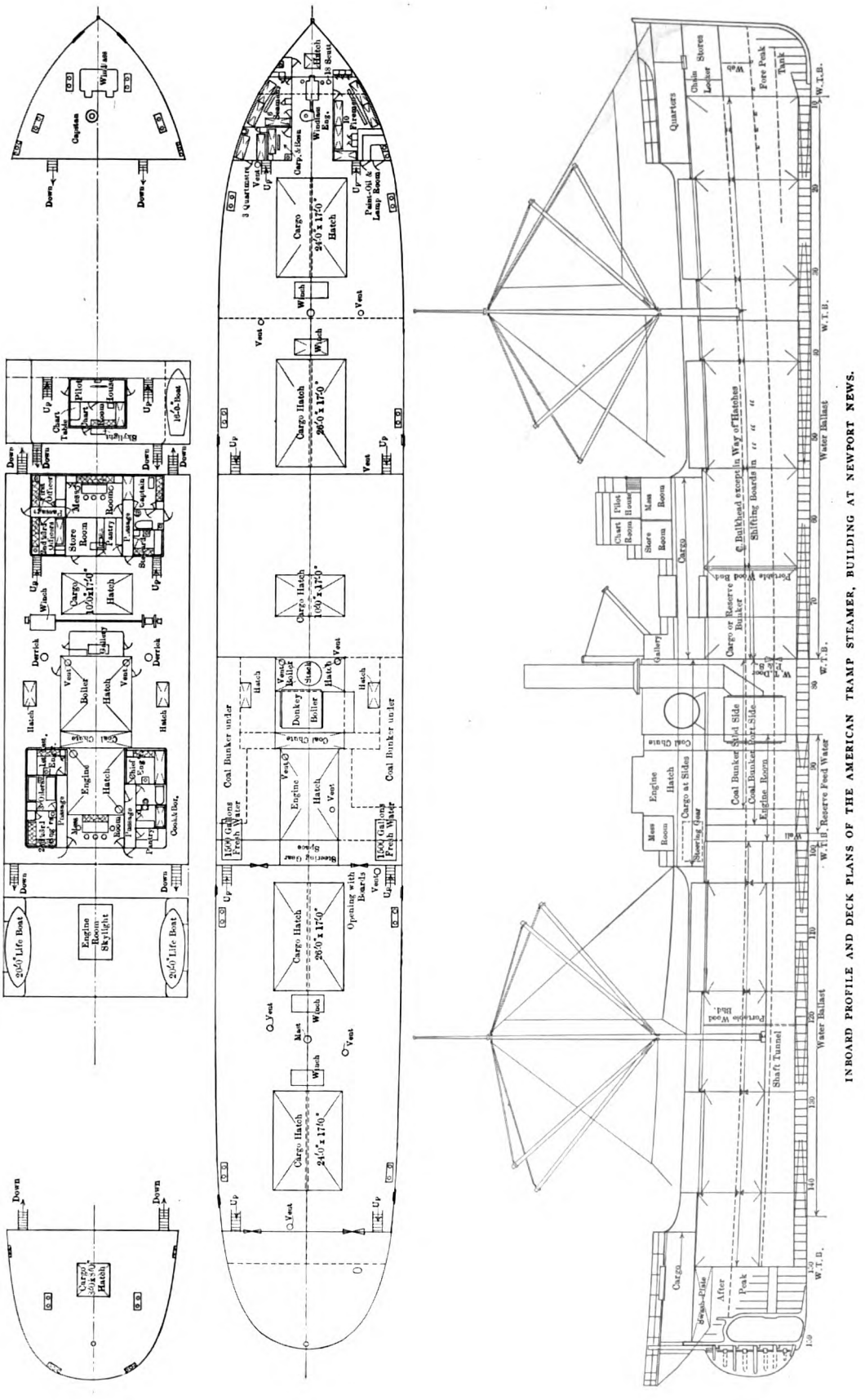

INBOARD PROFILE AND DECK PLANS OF THE AMERICAN TRAMP STEAMER, BUILDING AT NEWPORT NEWS.

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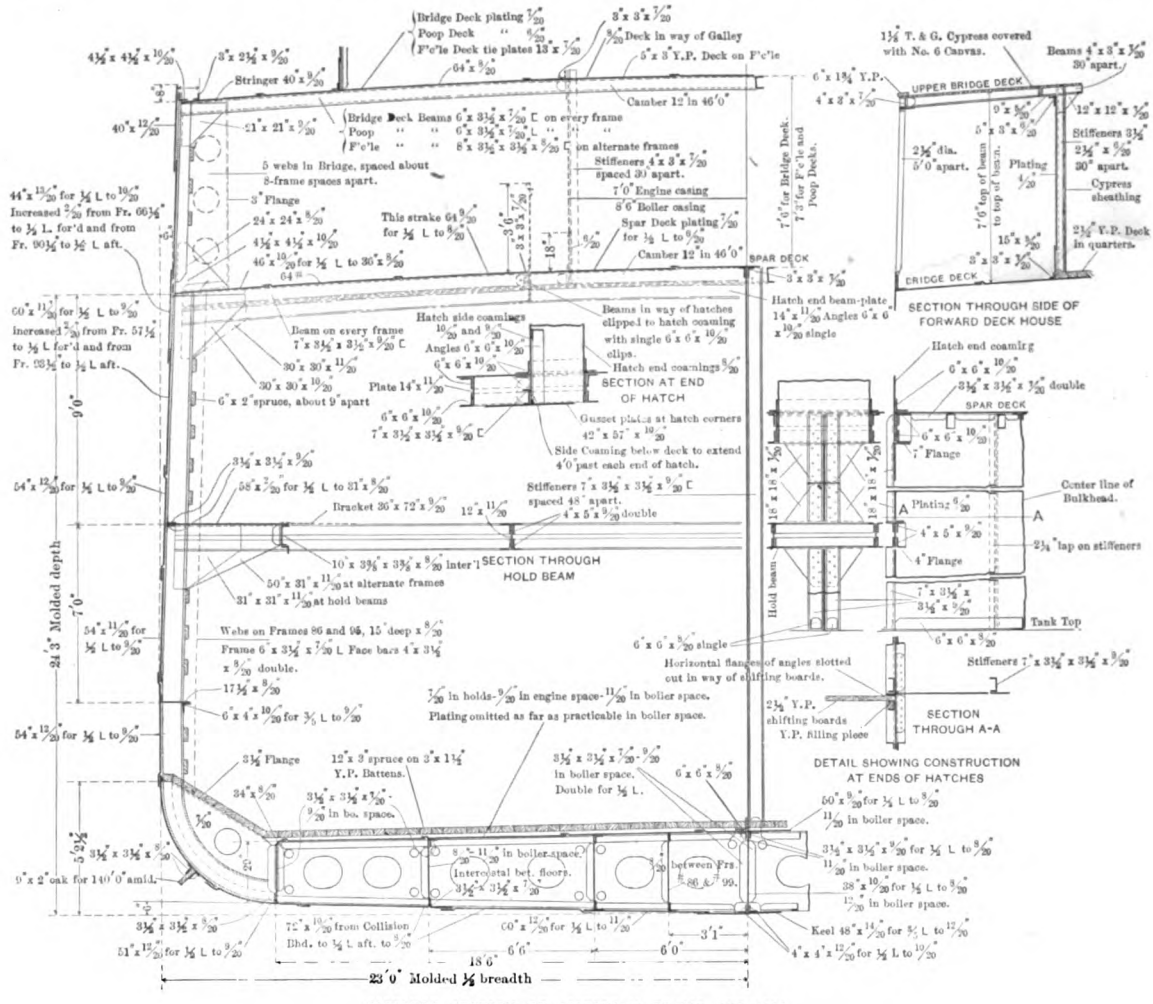
on account of the liability of the vessel being aground at times when loading. Between the peak bulkheads, deep channel framing is used, and in the peaks the ordinary angle and reverse frame construction. In way of the bridge, the frames are cut at the upper deck, and angle-bar frames are used between the upper and bridge decks. The upper and bridge decks are complete steel decks, with channel beams on every frame. At the hatch ends the deck beams are built up of plate and angles. Hold beams are built up of plate, with double angles top and bottom. The centerline bulkhead is stiffened by vertical channels, spaced 48 inches centers. Machinery casings of steel extend to the top of the bridge deck house. Wood ceiling is fitted on the tank top and bilge



MIDSHIP SECTION OF AMERICAN TRAMP STEAMER.

brackets, and cargo battens on the side frames throughout the cargo holds.

The cargo-handling gear consists of two booms on each side of the fore and main masts, and two derrick posts on the bridge deck with one boom on each. The booms on the masts are from 40 to 46 feet long, and those on the derrick posts 32 feet long. The latter are arranged so that they span the coal hatches as well as the bridge deck cargo hatch. For operating the main cargo booms, four Lidgerwood, double, 8¼ inch by 10-inch winches are provided, each winch having two drums and two gypsy heads, so that two cargo booms can be operated by one winch. At the midship hatch is a special winch for coaling. This will be operated by a single-cylinder engine, 6¼ inches by 10 inches, geared to an extended shaft athwartship, carrying at either end a friction drum and an extra large gypsy head. Each of the friction drums on all of the winches is fitted with the Lidgerwood double cone wood frictions, with patent cork inserts. These cork inserts have proved advantageous in that they have double the holding power of wood and engage with a lightness and ease which requires only half the effort on the part of the operator, thus enabling the operator to work his winch much faster, while at the same time saving himself much fatiguing labor. It is also claimed that the cork insert frictions are not affected by either oil, dirt or water. The frictions on all the winches are applied by an internal double cam arrangement and the end thrust on the cams is taken up by roller bearings. The friction levers in the cargo-handling winches are connected to the cams by gear wheels which permit the application of the frictions by a very small movement of the liners. Each drum has a hand brake applied by a foot lever. Hand levers are supplied over on each side of the engine, by which all the pet cocks can be opened or closed at once. All parts of the winches are made on the duplicate-part system.

The steam steering gear will also be supplied by the Lidgerwood Manufacturing Company, of New York, the engine being located at the after end of the engine casing on the upper deck level. One feature of the engine which is of importance is, that all the parts are made by gage, on the interchangeable-part plan, so that in case of breakage, wear or other need, new parts can be procured at almost instant notice, all fitted and ready to put in place. The worm wheel is of steel, with carefully cut teeth, and the worm is of bronze. The worm is in two parts for adjustment, to take up wear and prevent any backlash in the worm wheel, and a special feature is the use of roller-thrust collars at each end of the worm to save wear and give the greatest possible ease of operation. The cylinders are cast together as is customary, but this cast-

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ing is separate from the bed and the bed and side frames are all cast separately, in accordance with the Lidgerwood custom, and fitted together with planed joints, held in place by turned bolts, which fit into reamed holes. The design is such as to allow for long connecting rods, and these are fitted with the regular Lidgerwood gib and key strap ends instead of the usual bolt and shim ends.

There is a Hyde windlass and a steam capstan located on the forecastle deck, with the windlass engine on the deck below, from which both are driven. Baldt stockless anchors are fitted. The vessel is heated throughout by steam.

The main propelling engine is triple expansion, with cylinders 22 inches, 37 inches and 60 inches diameter by 42-inch stroke. Piston valves are fitted to the high and intermediate cylinders and a double ported slide valve to the low pressure. Separate liners are fitted in the high-pressure cylinder and for the piston valves and a false face for the slide valve. All valves are operated by Stephenson double bar link motion. Steam reversing gear of the direct type is provided. The bed plate and housing are cast iron of box section. The crank shaft is built up in three interchangeable sections. A horseshoe type of thrust bearing is fitted. The propeller wheel is a solid cast iron one with four blades. The main air pump is of the Edwards patent type, driven from the low pressure crosshead. Two main feed pumps, two bilge pumps and an evaporator feed pump are also driven from the air-pump beam. The surface condenser is separate from the main engine framing and has a cylindrical cast iron shell with 1,600 square feet of cooling surface. A centrifugal pump, driven by a single vertical engine is used for circulating water through the condenser. All independent steam pumps are of the Blake type and consist of a ballast pump 10 inches by 10 inches by 12 inches duplex, donkey pump 9 inches by 5¼ inches by 10 inches vertical duplex, and donkey boiler feed 4½ by 2¾ by 4 inches special duplex. There is also a 12-ton Reilley evaporator.

There are two main boilers, each 15 feet diameter by 10 feet 10 inches long, built for 180 pounds working steam pressure. Each boiler has three 46-inch corrugated furnaces with separate combustion chambers, and 313 3-inch tubes. The total heating surface of both boilers is 4,400 square feet, and total grate surface 149.5 square feet. For supplying steam to the winches and for general harbor use there is a donkey boiler of the Scotch type located on the upper deck level above the main boilers. This boiler is 9 feet diameter by 10 feet 5½ inches long, and has one 52-inch corrugated furnace, 108 3-inch tubes and is built for a working pressure of 90 pounds per square inch.

THE SUCTION DREDGER LEVIATHAN.*

BY ANTHONY G. LYSTER AND W. BOYD.

The continual growth in the depth and size of steamers, which has culminated in the *Lusitania* and *Mauretania*, each drawing as much as 35 feet of water, has made it desirable to improve the existing depth of the bar channels of the Mersey, and, with this object in view, the Mersey Docks and Harbor Board in 1907 resolved, on the advice of their engineer, to construct a dredger of 10,000 tons capacity, and capable of dredging to a depth of 70 feet from water level to the bottom of the channel. This is necessary, having regard to the great range of tide at Liverpool, which amounts in the spring to as much as 31 feet. This dredger, known as the *Leviathan*, which has been built by Messrs. Cammell, Laird & Company, at their Tranmere Shipyard, is of the twin-screw, self-propelling hopper type, having a net hopper capacity of 180,000 cubic feet, and capable of filling herself with 10,000 tons of clean Mersey sand in fifty minutes from a maximum depth of 70 feet.

The principal dimensions are:

Length between perpendiculars.....	465 feet 9 inches
Breadth, molded.....	69 feet
Depth	30 feet 7 inches

Under ordinary working conditions and in normal steaming trim, with the full load of 10,000 tons of sand in the hoppers, and with coal bunkers and water tanks full, the vessel is capable of traveling at the rate of 10 knots, the mean draft being 23 feet. The propelling machinery of the ordinary triple-expansion inverted marine type, with cylinders 22½ inches, 37 inches and 61 inches diameter, and 45-inch stroke, is by D. Rowan & Company, Glasgow, who also supplied the boilers, four in number, 16 feet diameter and 11 feet 9 inches long, working under a pressure of 180 pounds per square inch with natural draft.

The framing and plating are of steel throughout, and the scantlings generally have been arranged to meet the requirements for the 100 A1 Class in Lloyd's Register. There are eight complete athwartship watertight bulkheads extending to the upper deck, and five others, which are watertight, inside the hoppers only. There is also a center line watertight bulkhead, which extends from the fore end of the buoyancy space immediately in front of the hopper to the after end of the boiler room, thus dividing the hopper into twelve watertight compartments. The total number of watertight compartments in the ship is twenty-five, and they have been arranged with a view to complete safety should any two compartments become flooded. All the usual and necessary watertight doors and passages have, of course, been provided. The hopper itself is 162 feet long, and is 49 feet wide at the deck level; each of its twelve divisions has thus a section at its upper part of 27 feet fore and aft by 24 feet 6 inches athwartships. This rectangular section extends for a depth of about 20 feet, from which point the four walls of the compartment are sloped inwards, until they reach the bottom and terminate at the edge of the valve-discharge opening, which is circular and 5 feet 6 inches diameter. The side walls of the hopper, which are also watertight, form the inner walls of the side buoyancy spaces as shown.

The main idea of dredging and depositing the sand is simple enough; that is to say, sand and water are sucked up from the dredging level through long pipes by means of centrifugal pumps, and discharged by them into the hopper, where the sand settles to the bottom and the water is allowed to flow overboard from the top. The sand is finally discharged from the hopper in the desired locality by means of the discharge-valve openings in the bottom of each compartment. It is, however, in the detailed arrangement, by means of which this simple programme is carried out on an immense scale, that the interest lies.

The dredging machinery consists of four centrifugal pumps specially constructed by Gwynnes, Ltd., of London, for pumping sand, each pump being driven by a separate set of engines, and having a separate suction pipe fitted to the side of the vessel. This machinery is situated in the pump room immediately abaft the hoppers, the suction pipes being led where necessary through the side buoyancy spaces to the openings in the sides of the vessel. The engines are of the inverted triple-expansion surface-condensing marine type, with cylinders 15 inches, 25 inches, 40 inches by 18 inches stroke, working at 180 pounds pressure, and each set is directly coupled to its corresponding pump. Each of the four pumps has a suction and discharge aperture of 42 inches diameter, the suctions being of the double inlet type. The casings are of cast iron in halves, with portable centers on each side for the removal of the impellers, which are of cast steel and 6 inches wide at the

* From a paper read before the Institution of Naval Architects, April, 1909.

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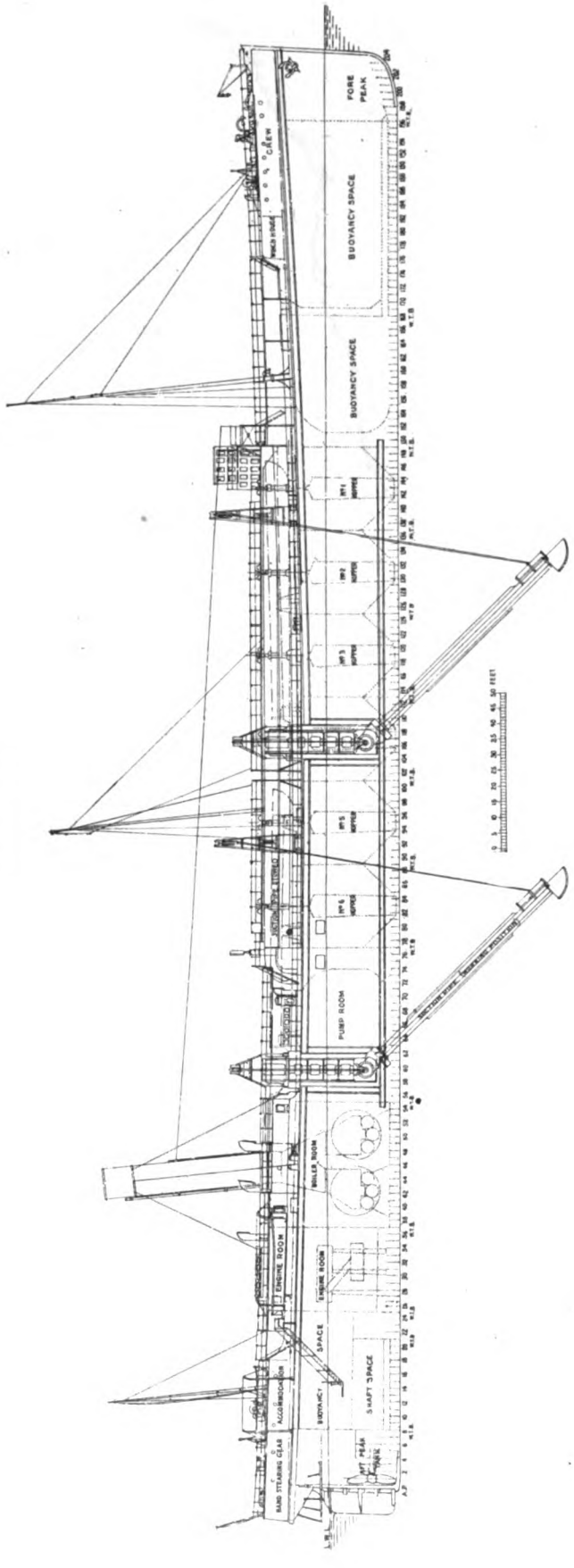

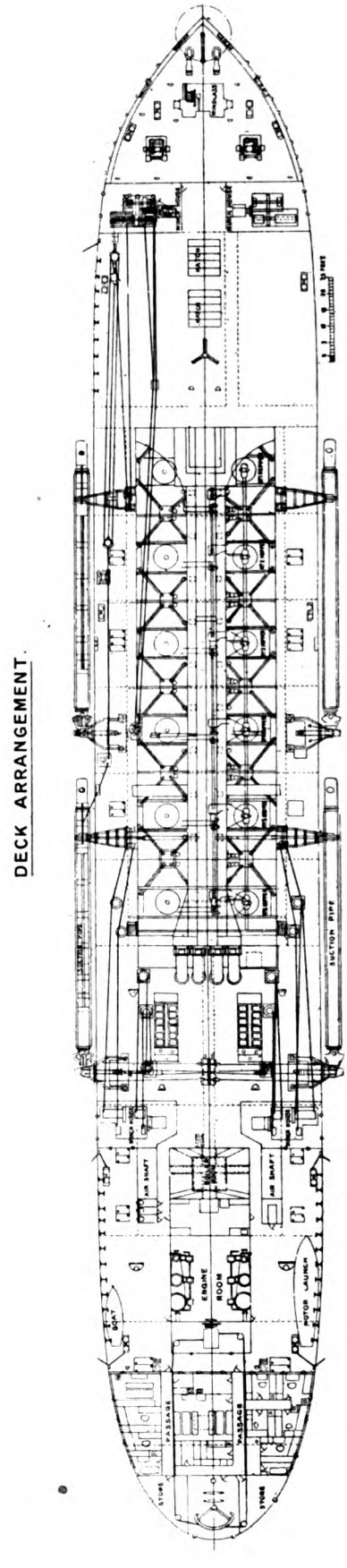

FIG. 1.—PROFILE AND DECK PLAN OF THE LEVIATHAN.

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the tips of the blades. A sluice valve, operated hydraulically, is fitted between each suction and the ship's side, the lever and rods for working being brought within easy reach of the starting platform.

One of the most important points in the whole of the dredging system, and one which may be regarded as vital for the successful working of the dredger, is the design and arrangement of the suction tubes and their attachment outside of the vessel. They are four in number, two on each side of the vessel, situated as indicated on Fig. 1. It will be seen that the lead of each tube is forward, and they are of such a length as to enable dredging to be efficiently done in a maximum depth

As it was necessary to arrange for a lateral motion of the nozzle as well as a vertical one, the joint forming the attachment of the tube to the ship's side needed special and careful treatment in its design. It is formed by a cast steel swivel band, held up to a cast steel sliding flange by a ring of the same material, secured by steel studs and gunmetal nuts suitably locked. There is a heavy horn bracket with a brass bushed bearing for supporting the outer end and for lifting, and the swivel portion is of cast steel, with large bearing pins working on adjustable bearings. The upper bearing and bracket are removable for overhauling, and are fitted with recess and spigot to secure alinement. This bend acts as a

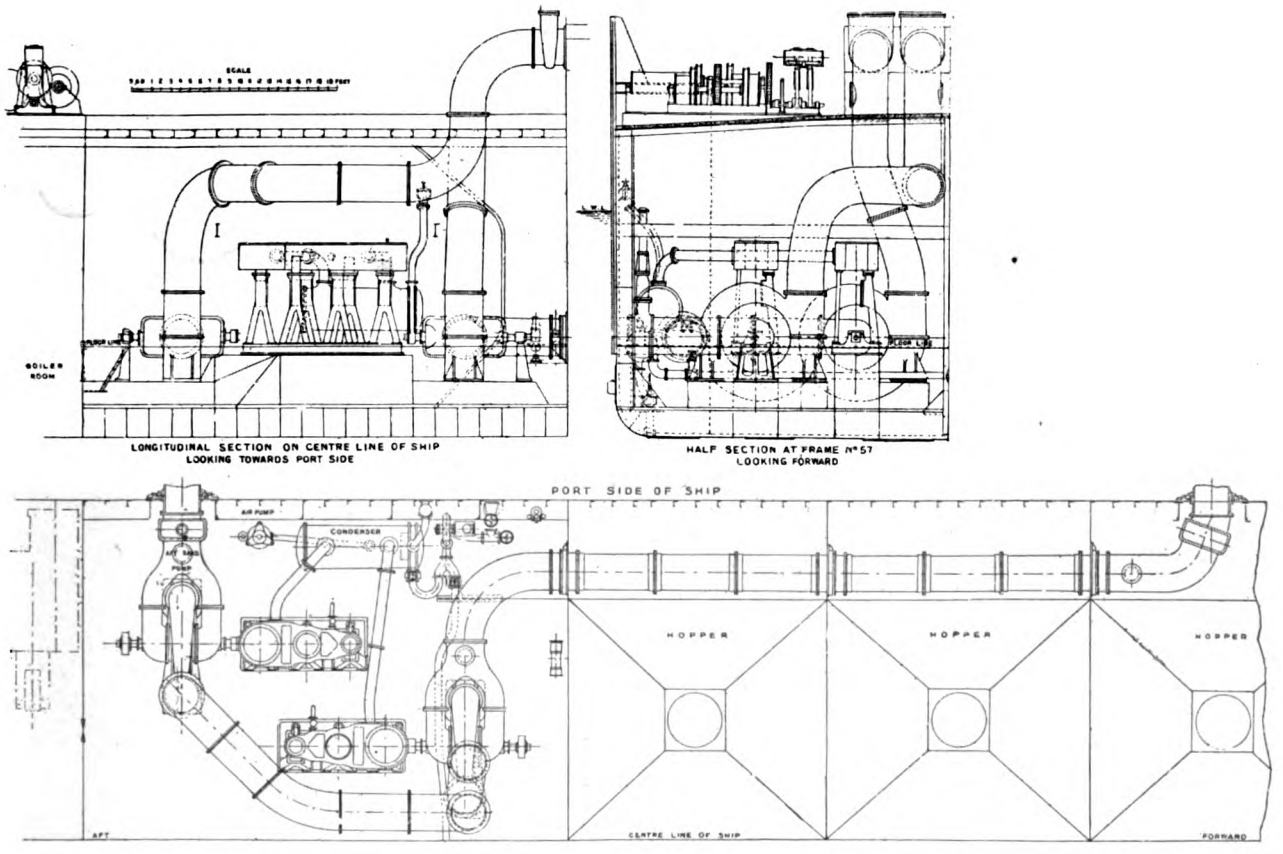

FIG. 2.—ARRANGEMENT OF MACHINERY IN PUMP ROOM.

of water of 70 feet, the depth being measured from the surface of the water to the surface of the sand; the angle of inclination of the tube does not exceed 45 degrees below the horizontal when dredging at the maximum depth. These tubes are made of wrought-steel boiler plates, the top half of the circumference being 8/20 inch thick, and the bottom 9/20 inch, with the circumferential joints quadruple riveted with single outside straps. Within each tube a midfeather plate is fitted for three-fourths of the length, extending at the sides between the angles connecting the upper and lower halves of the tube. An elm rubbing piece, fitted between large angles, runs along each side of the pipe, and a fender plate extends for a length of 30 feet on the rubbers, where chafing is likely to occur against the ship's lower side rubber. At each end of the tube, cast steel flanges are riveted for the purpose of connecting it to the swivel joint and nozzle. The nozzle itself consists of a cast steel flange and end grating, with a wrought steel body efficiently stayed. Elm rubbers are fitted on each side, and a manhole with cover is provided, while on the upper side of the tube near the nozzle there are suitable lifting brackets of forged steel.

trunnion or hinge, by which the tube is free to turn either about a vertical or horizontal axis, while the sliding flange works in a cast steel frame riveted to the ship's side, the guide bars being of wrought steel. By this means the tube can be raised bodily to the deck level and brought inboard, where provision is made for stowing it.

The raising and lowering of each tube is effected by two derricks, one at each end of the tube, both being worked from the same steam winch on deck. In connection with these jibs special cradles are provided to carry the frame supporting the swivel bend, with screw gear to move the cradle inboard or out as required. All the fittings in connection with the jibs are specially strong, and an emergency gear is provided for each tube, so that in case of a breakdown of the suspension rope or attachment to the suction head when the tube is below the water, the tube can be easily raised again. The gear consists of a spare length of wire rope, stowed, when not in use, along the outside of the tube. One end is attached to the suction head at the bottom and the other accessible from the deck when dredging is going on, a special sheave and lead to the winches being also provided on deck.

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The four winches necessary for manipulating the tubes are each provided with four drums arranged in pairs, two for moving the derricks in and out, and two for raising and lowering the tubes, and are actuated by double-cylinder reversing steam engines. Each drum can be driven separately, and is capable of exerting a direct pull of 10 tons, and the machinery is so arranged that one man can control the whole of the movements required to be made by a suction tube; that is, adjustment in dredging position, hoisting and bringing inboard. These operations are directed by a "tubeman" at each tube, stationed at the ship's side directly over the place where the mouthpiece is located. This man constantly takes soundings by means of a line attached to the suction head, and also watches the vacuum obtained in the pumps, a very variable quantity, varying from 5 inches to 15 inches, which is indicated on a gage placed conveniently near. By these observations he is enabled to give the necessary directions to the winchmen for the manipulation of the tubes to keep the suction head up to its work with the maximum efficiency.

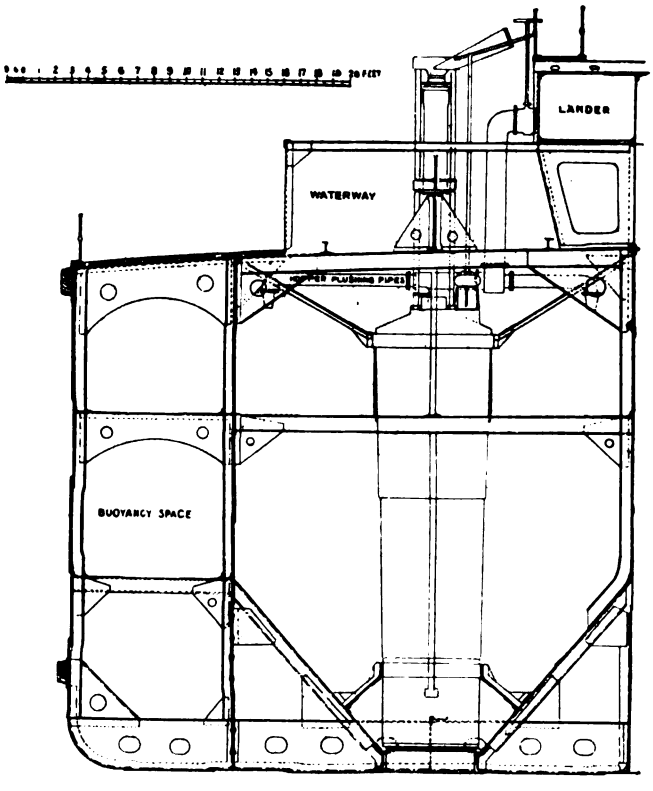

FIG. 3.—SECTION IN WAY OF HOPPER.

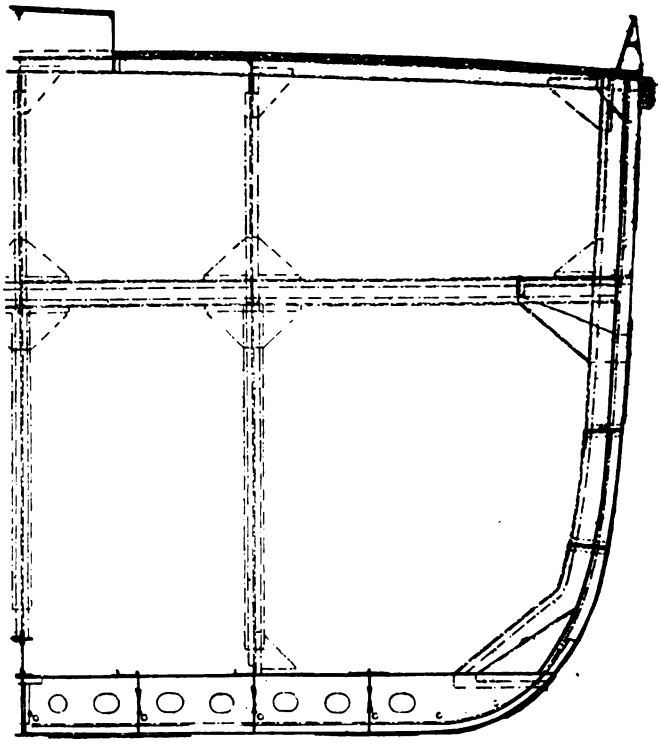

FIG. 4.—SECTION THROUGH FORWARD BUOYANCY SPACE.

The mixture of sand and water on leaving the pumps is discharged through two ducts or "landers" of rectangular section extending the full length of the hoppers. These landers run side by side, their common center wall being an upward extension of the center-line bulkhead; they are each 6 feet wide by 4 feet 3 inches deep, and are supported by brackets attached to strong thwartship beams. The bottom of each lander is covered with cement 2 inches thick, with a view to protecting the steel from the scouring action of the sand. The admission to the hoppers takes place through gate valves in the bottom of the landers; there are two to each compartment, with the exception of the end ones, and the openings are rectangular, 2 feet 6 inches by 11½ inches. At the extreme forward end the landers spread out in section to the full width of the hopper, in order to lessen the velocity and shock on the end bulkhead.

In order to obtain effectively a rapid settling of the sand in the hoppers it is essential that the velocity of the mixture should be reduced as nearly as possible to zero. Below the deck level in each of the twelve hoppers this takes place, naturally, while above this level a coaming, standing 7 feet above the deck, is provided all round the hoppers, forming a huge tank in which the large excess of surface water is brought virtually to rest. It is finally drained off over two weirs placed at the after end of the hoppers, escaping over side by means of four ducts, two on each side of the vessel. That this procedure is highly effective in separating water and sand may be seen by curves plotted to show the relative percentages of solid contained in the mixture while coming in through the landers and going out over the weirs during one loading of the vessel.

The process of discharging the sand from the hoppers, ordinarily known as "dumping," is carried out by means of Mr. A. G. Lyster's hydraulic valves, which have proved themselves so uniformly effective in other dredgers belonging to the Mersey Dock and Harbor Board. These valves are essentially large cylinders, extending from the valve opening (5 feet 6 inches diameter) in the bottom of each hopper to the deck level, and are operated by hydraulic rams, one to each valve, mounted on strong fore-and-aft girders, as shown in Fig. 3, the lift of each valve being 4 feet. In the crown of each hopper valve is fitted a special "surface-water" valve, worked by hand, the function of which is to drain off the surface water remaining on top of the sand and below the level of the weirs on the completion of the load; the interior of the hopper valves being, of course, open to the sea.

The hydraulic installation is necessarily of a powerful kind, and consists of one set of inverted high-pressure condensing engines and three single-acting main pumps, driven direct from piston rod cross-heads. The pump rams are 5 inches diameter, the stroke 15 inches, and the hydraulic pressure 800 pounds per square inch, working with a steam pressure of 100 pounds.

Owing to the tendency of the sand to consolidate and harden in the hoppers, a system of flushing pipes is arranged, as shown in Fig. 3. By means of these the sand can be loosened in discharging, and the hoppers effectively washed out. The

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water for this system is supplied by the main pumps from the "landers," each lander having a closing door near the forward end of the hoppers, which permits the ordinary flow to the forward hopper to be stopped, and a pressure head created for the flushing system. The ordinary gate valves in the bottom of the landers are, of course, closed during the flushing operation. The efficiency of the means for getting rid of the sand may be judged from the fact that a load of 10,000 tons has been disposed of in the short space of ten minutes.

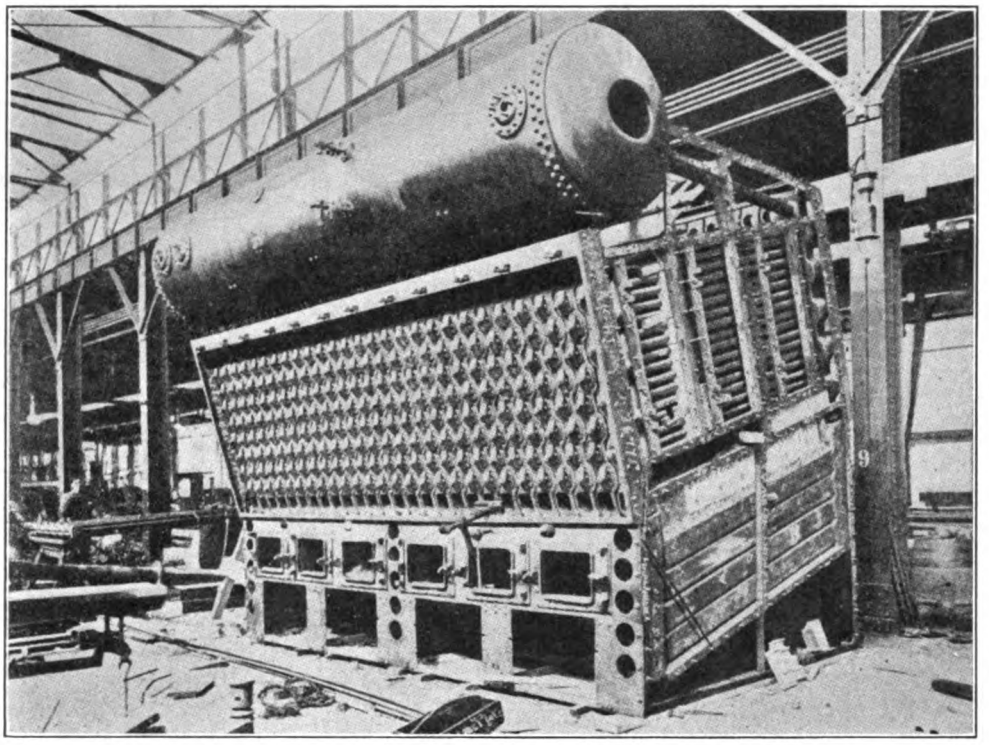
The vessel is lighted throughout by electricity, and the excellent accommodation provided for the working staff and crew is a feature which will conduce very largely to the working efficiency of the dredger. Ample spare gear is, of course, provided in view of the heavy and continuous nature of the work, and among other items might be mentioned the two spare suction tubes, complete and ready for mounting, which are kept in readiness.

The trials of the vessel gave very satisfactory results. The average speed on the measured mile was 10.48 knots, and the consumption of coal on a six hours' run was 1.3 pounds per indicated horsepower per hour, as against 1½ pounds, the contract limit. The boiler power proved very ample, so that the steam required was fully provided without any forcing. The sand pumping also gave very satisfactory results, although the material was not the "clean Mersey sand" to which the specification applies in the case of the trials, which requires the full load of 10,000 tons to be pumped in fifty minutes. On the occasion of the trials, pumping proceeded at a rapid rate until the pipes reached a stratum of material into which they would only penetrate very slowly, so that the rate of discharge fell off. Even under these disadvantageous circumstances the vessel loaded to within 7 percent of her full load in fifty minutes, and there is no doubt that in the specified material she will do the whole load in less than the time named. In the case of the Board's other dredgers the record loads have been done in the course of the ordinary work, so that a similar performance may be expected from the Leviathan in service.

NAVAL BOILERS IN SERVICE.

BY LIEUT. H. C. DINGER, U. S. N.

In the fleet that encircled the globe there were the following types of boilers: Double-ended Scotch boilers (working pressure 180 pounds) in the *Kearsarge* and *Kentucky*, single-ended Scotch (working pressure 180 pounds) in the *Wisconsin, Alabama* and *Illinois*, Thornycroft boilers (working pressure 230 pounds) in the *Missouri* and *Ohio*, Niclausse boilers (working pressure 265 pounds) in the *Georgia, Virginia* and *Maine*, Babcock & Wilcox boilers (working pressure 265 pounds) in the *Nebraska, New Jersey, Rhode Island, Louisiana, Connecticut, Vermont, Kansas* and *Minnesota*. The cruise has been in a large measure a good test of the lasting qualtities, reliability and adaptability of various types of boilers to conditions of extended cruising, and a review of the relative advantages developed, repairs now necessary and their general economy in coal consumption and repairs, is one of the valuable lessons that can be drawn from the steaming results and the general condition of boilers on their arrival on the Atlantic Coast.



ASSEMBLING A BABCOCK & WILCOX BOILER, SHOWING EASE WITH WHICH PARTS MAY BE REMOVED.

COMPARATIVE CONSUMPTION OF COAL.

Complete figures for coal consumption for the run home are not at hand at present, but the total consumption of the vessels while running in company from San Francisco to Manila was published some time ago. The results are as follows: The average consumption of the *Connecticut, Louisiana, Kansas, Vermont, Minnesota, Nebraska, Rhode Island* and *New Jersey* was 5,481 tons. The trial displacement of these vessels is 15,625 tons. The average consumption of the *Georgia* and *Virginia* was 5,873 tons. The average trial displacement of these vessels is 15,000 tons. The average coal consumption of the *Ohio* and *Missouri* was 5,600 tons, the trial displacement being 12,500 tons. The average consumption of the *Kearsarge, Kentucky, Illinois* and *Wisconsin* was 4,878 tons, the average trial displacement being 11,536 tons.

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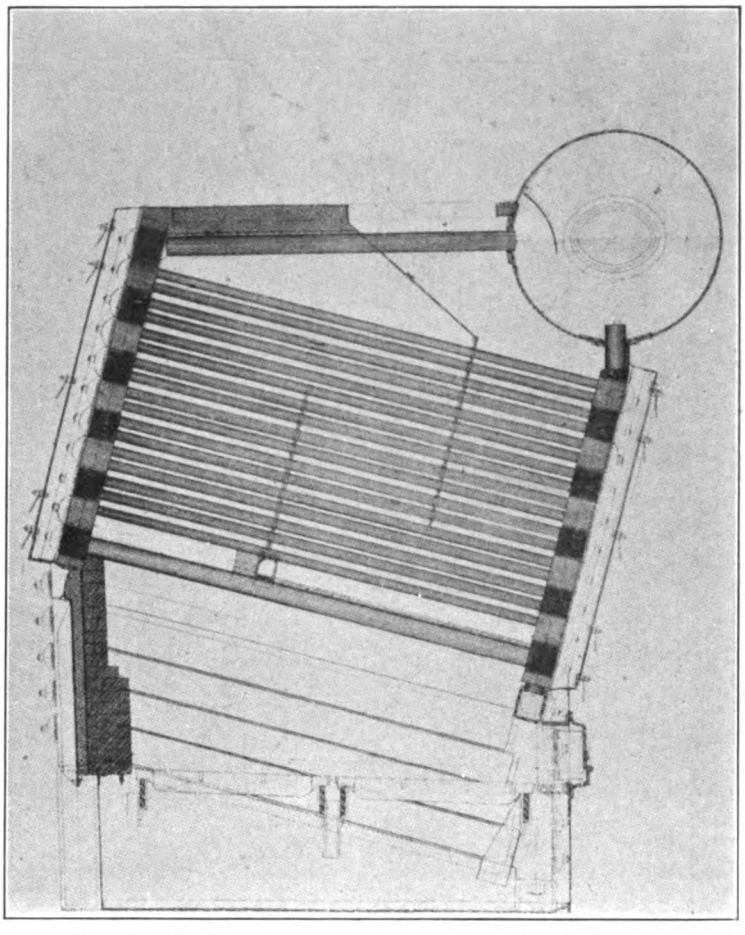
As the vessels differ in displacement, they should all be reduced to a common basis in proportion to the two-thirds power of their displacement. When this is done, the result is as follows:

	Tons.
Babcock & Wilcox vessels	5,481
Niclausse vessels	6,033
Thornycroft vessels	6,359
Scotch vessels	5,971

The saving of the Babcock & Wilcox boilers over the other types is thus: 552 tons over the Niclausse, 878 tons over the Thornycroft and 490 tons over the Scotch boilers. This is the result of only three months' service, steaming from San Francisco to Manila, via Australia. With this same proportionate saving carried on over several years it would soon cover the entire cost of boilers. This increase in economy, of course, means a corresponding increase in the steaming radius.



SIDE ELEVATION—BABCOCK & WILCOX BOILER, SHOWING BAFFLING.

GENERAL CONDITION AND OPERATION.

The Scotch boilers on the older vessels have been in constant service for eight or nine years, and are to a considerable extent worn out. These boilers now require a very considerable amount of repairs, and the question of reboilering these vessels with watertube boilers is now being considered. By reboilering with watertube boilers considerable weight can be saved.

The Thornycroft boilers on the *Missouri* and *Ohio* have worked very successfully. They have been in service six and five years respectively, but now require retubing, and their brick work and casing also need considerable attention.

The Niclausse boilers on the *Maine* have never operated with any commendable degree of satisfaction, and the troubles, begun very early in the vessel's career, apparently have never been successfully overcome. This vessel has been very uneconomical, both as regards coal consumption as well as in engineering repairs. It may be fair to say that this condition is not entirely due to the boilers, but undoubtedly the boilers can well be charged up with a considerable share of the bad repute. The Niclausse boilers on the *Virginia* and *Georgia* are of a later type than those of the *Maine*, and have, during the three and two and one-half years of their service, given better satisfaction. The *Virginia* has, however, required a considerable amount of repair work to her casings, and the *Georgia* is also in need of considerable repairs to the brick setting of her boilers. The casings of Niclausse boilers in other vessels, such as the *Pennsylvania* and *Colorado*, have also given a great deal of trouble.

The Babcock & Wilcox boilers on the other eight vessels of the fleet have practically no repair work outside of the capacity of the ship's force; some of the boiler fittings, in common with those of the other vessels, require renewal and repairs.

Some of the principal causes for trouble are leaky bottom-blow valves. These valves have been the ordinary heavy bronze stop valves, and it has been difficult to keep these tight. A new valve of plug type, designed so as to prevent sediment cutting its seat, is being experimented with, and the use of valves with nickel seats and discs has also been suggested. In a number of cases some of the internal feed pipes have become detached, which defect is to be remedied by a new design of internal feed arrangement. Defective tubes have been discovered from time to time in all of the different types of boilers. To guard against this it is necessary to have the

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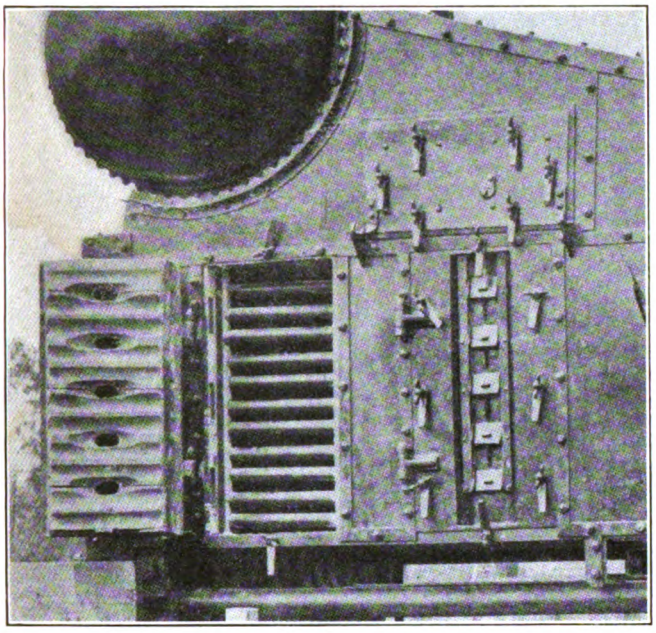
very best material and to arrange the tubes so that corrosion and wear are reduced to a minimum.

The manner in which boilers are treated by the operating personnel and the hard or easy conditions under which they are caused to operate will, of course, have its full effect on the lasting condition of any boiler, and that boiler which can withstand most neglect and bad treatment without serious loss of efficiency has a most material advantage; for rough usage may of necessity be brought upon it on a naval vessel during war time.

Should defects in the tubes or pressure parts develop it is most important that they be easily remedied or repaired. The



CLEANING DOORS—BABCOCK & WILCOX BOILER.

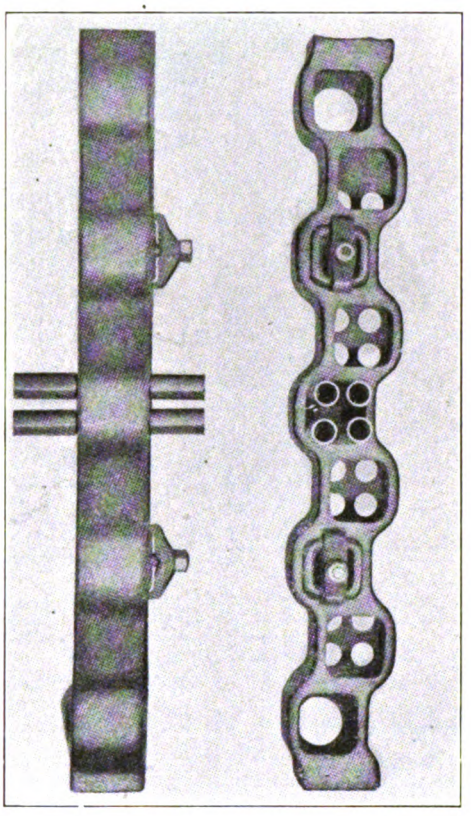
ability to make good a defective tube is, however, a point wherein the different types differ. In the Babcock & Wilcox boiler the ends of the defective tube may be plugged by simply lowering the water in the boiler, taking off the hand-hole plates at each end of the tube, inserting the plugs, refilling and starting up again. With the Niclausse boiler, the defective tube can be withdrawn and a spare one inserted, which would require about the same time as to plug a tube in the Babcock & Wilcox boiler, but while it is comparatively easy to locate a leaky tube in the Babcock & Wilcox boiler, it is a much more difficult matter to locate a small leak on a Niclausse boiler. On the Thorncroft or others of the express type it is also much more difficult to locate a small leak. And to do so it is necessary to cool the steam and water drums so that a man may get into each, and when the tube is located the plugging must be done from the interior of these drums. In the case of the Niclausse or Babcock & Wilcox boiler, the work of plugging or renewing of the tube is done by a man outside of the boiler. The Babcock & Wilcox boilers use an ordinary boiler tube which can be obtained at almost any large commercial center. The Niclausse boiler tubes are of special make, and for this reason cannot be as readily supplied in distant lands. To renew a tube in the Babcock & Wilcox boiler, each tube can be taken out separately by itself, no others being disturbed. In express boilers, except for a very few tubes, quite a number of good tubes may have to be cut out in order to get at the defective one. In some types of express boilers it is practically impossible to put in new tubes with the boilers in the vessel. In the express boilers, when a defective tube is discovered, it is usually plugged, and the process continued till there are so many plugged that the big job, often outside the capacity of the ship's force, of cutting out and replacing defective tubes is undertaken at a navy yard.

With the large tube boiler, arranged for independent examination and withdrawal of tubes, a defective tube can be renewed at once. Usually you never stop to plug a tube, as a new one can be put in in very little extra time, so these boilers can be kept in constant repair by the ship's force. This is of immense military advantage, and though the arrangements necessary cost something and also add weight, they are well worth the price, because you can have a boiler always ready for service and not one with a large percentage of the tubes plugged off.

It is possible to go thoroughly all over a boiler of this type, replacing any part desired, while at the same time having the boiler ready for steaming in a few hours in case it is required.

GREASE, SALT AND SEDIMENT IN TUBES.

These are conditions which many will say should not exist, but the fact is they do exist, and while it is sometimes possible to keep all three—grease, salt and sediment—out of the boiler, conditions do and will continue to arise where you will



FORGED STEEL HEADER—HANDHOLE COVERING GROUP OF FOUR 2-INCH TUBES.

have them. This being so, the proposition then is how can they be gotten rid of and how can their presence be told before their ravages have become extensive? It is most important to be able to know the exact condition of the heating surface so that precautionary measures may be taken. Of course, a great deal can usually be done by use of soda or other cleansers and frequent blowing, but for thorough cleaning the heating surfaces should be capable of being looked at and accessible to cleaning by direct mechanical means. In the Niclausse boilers the field tubes do not drain, so these methods are not very effective, and the only effective way of getting the tubes clean is to remove the tubes and clean and replace them individually, a matter entailing a great deal of labor and also very careful work in replacement.

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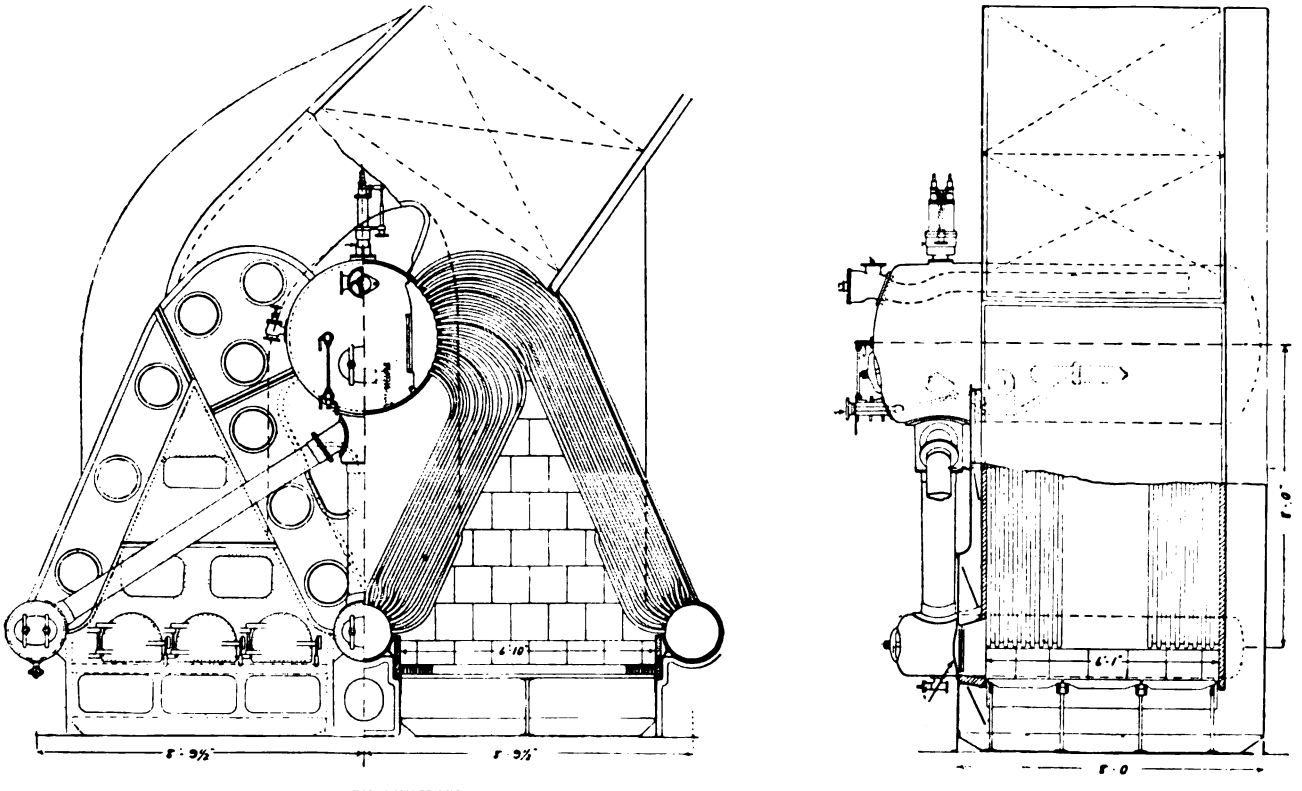
In the Babcock & Wilcox boilers each tube can be examined its full length and its surface thoroughly cleaned either with turbine cleaners, scrapers or brushes. In the express type of boiler this examination must be made from the interior of the drums, and if the tubes are bent the condition of their interior surfaces is never known. With the Babcock & Wilcox boiler any tube can be thoroughly examined inside of a few minutes. Thus any start at corrosion or wearing away can be detected and often remedied before it becomes a matter of importance.

PRIMING AND SCALE FORMATION.

One of the things that it is most desirable to avoid is priming. Some boilers guard against this by the use of steam drums. Small tube or express boilers are peculiarly subject to priming when using salty or brackish water. Of course, boiler water is always kept as fresh as possible, but there are



THORNYCROFT BOILER, AS INSTALLED ON UNITED STATES BATTLESHIPS.

often unavoidable leaks in the condenser or other connections whereby salt water gets into the boiler. Sometimes there may not be time to repair the salt leak, and under these conditions a boiler that can be operated with salty water without priming has an advantage of considerable importance. One of the greatest drawbacks of the small tube or express boilers is the excessive priming when water that is at all salty is used. The recent trouble with the boilers of the *Salem* at Charleston is an extreme example of this.

Large tube boilers can be operated with salty water, and the Babcock & Wilcox boiler has repeatedly demonstrated its ability, on the around-the-world cruise, to operate without appreciable priming, even with a fairly high degree of saturation. Boilers employing the field tube do not operate successfully with salty water, and as sediment cannot be easily blown out, there is a much greater tendency to form scale. Thus the use of salt water in such boilers is attended with danger and difficulties.

In express boilers, when any scale has formed, there is much more danger of leaky or burnt-out tubes than in the Babcock & Wilcox or Scotch boilers, and when these troubles appear in small tube boilers the tube ends are not as easily accessible, and renewals are difficult to accomplish. Where small tubes are used, especially if bent, there is considerable danger in the scale deposit forming to such an extent in certain places as to cause the tube to be partially or entirely plugged. If scale should form in a boiler with straight tubes and accessible ends, the deposit can be thoroughly and easily cleaned out of the tubes, either by the use of scrapers or turbine cleaners. When scale or sediment of more than 1/16 inch thickness forms in small tubes (1½ inches diameter or less) it defies removal, either from straight or curved tubes, as no turbine cleaner of such small size can be made with parts sufficiently strong to stand up to the work.

COLLECTION OF SOOT ON HEATING SURFACES.

In continuous steaming all boilers gradually collect a considerable quantity of soot on their heating surface. This collection reduces both the capacity and economy of the boiler to a very great extent, and hence a most vital point in the design of a successful boiler is the ease, feasibility and thoroughness with which this collection of soot may be removed while the boiler is steaming.

The ability to remove soot from the heating surface, while steaming, is one of the cardinal advantages of the Babcock & Wilcox boiler. By means of a steam or air lance, operated through the dusting doors provided in the sides of the casing, the soot is dislodged, and either carried up the smoke-pipe by the draft or it drops down and lodges on the horizontal baffle laid over the row of 4-inch tubes immediately above the fire. By means of a door in the casing, this horizontal baffle can be thoroughly cleaned of the soot. So the boiler can be cleaned at any time and kept clean while steaming. In other types of boilers the means for cleaning tubes of soot while under steam are defective, and in no types yet put into use have the facilities for thoroughly cleaning the fire-sides of soot approached in any respect those provided with the latest type of Babcock & Wilcox boiler. This advantage looms up particularly when steaming long distances at high power. Though

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many boilers show good results when starting out clean, as soon as the soot deposit becomes considerable the economy and free steaming of the boiler disappear or drop very materially.

ARRANGEMENTS FOR BAFFLING GASES.

The economy of a boiler depends to a considerable extent upon the arrangements provided for baffling the gases of combustion and conducting them along the heating surface so that it will be most effective. The arrangement of the Babcock & Wilcox boilers allows for three passes across the nest of tubes. This brings about a rapid flow of gases past the heating surface at right angles to the length of the tubes and also keeps the gases in contact sufficiently long to enable practically all the available heat to be extracted, without a large ratio of heating to grate surface. The up-take temperature on Babcock & Wilcox boilers is remarkably low, and with good firing the temperature at the end of the last pass seldom exceeds 500 degrees F., even with as much as 2 inches air pressure.

The Niclausse boilers are not as well baffled. Their up-take temperatures are higher, and there is consequently a much greater loss of heat passing up the smoke-pipe. Considerable difficulty is experienced in Niclausse boilers in securing baffling in place, and burning out the baffling tubes is a constant source of trouble.

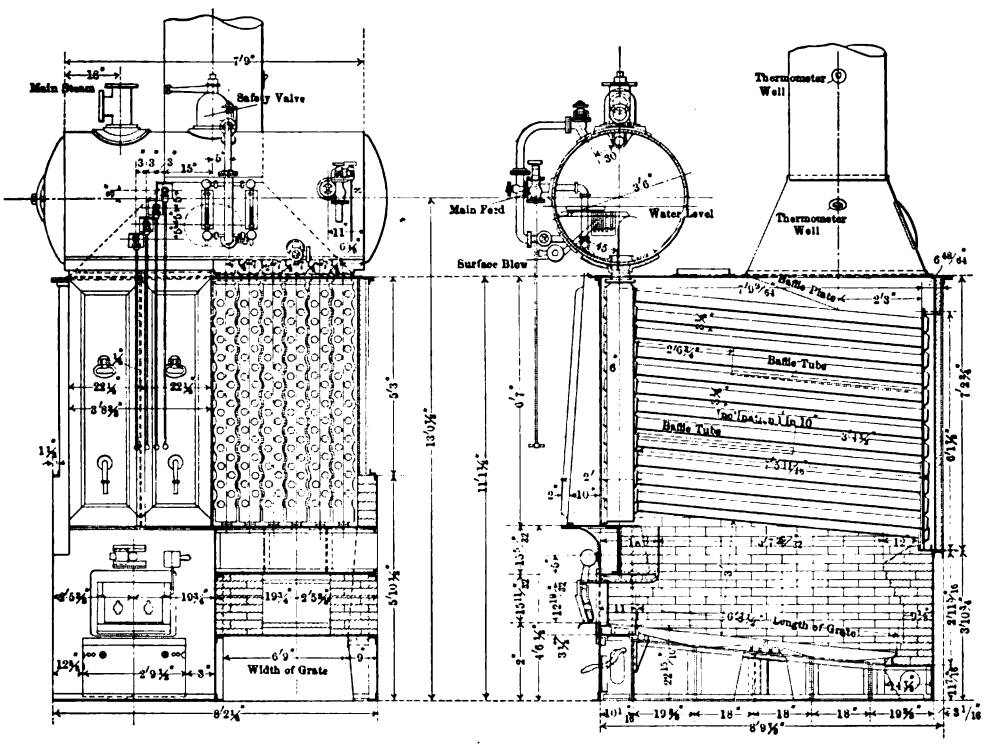
Most types of express boilers are not well baffled to secure good economy and low up-take temperature. Owing to structural features in most types of express boilers satisfactory baffling cannot be fitted; frequent attempts at baffling these boilers have resulted in forming pockets from which it is practically impossible to remove soot and ashes.

DURABILITY AND ACCESSIBILITY OF BOILER CASING.

Another important feature from an operating point of view is the durability of the boiler casing and the ease with which damaged parts may be replaced. The sides and backs of the Niclausse boilers are built up largely of brickwork, and in service this brickwork, due no doubt largely to the movement of the vessel, shock of firing guns, etc., cracks and deteriorates, so that considerable repairs are frequently necessary. Distortion of the casing, due to overheating, has also been experienced. The upkeep of the casings and brickwork of Niclausse boilers thus far used in service has been a matter of considerable expense.

Express boilers also require a considerable quantity of brickwork, which in many places requires frequent and continued renewal, also due to the positions of the lower drums; a considerable portion of the casing is in a position where conditions tend to corrosion and where examination and repairs are very difficult and in many cases impossible.

The durability and the ease with which any part of the casing of the Babcock & Wilcox boiler used in the United States navy can be replaced by unskilled labor has been well demonstrated in the fact that there have been practically no repairs necesary to the casing of any of the later type of this



NICLAUSSE BOILER, AS INSTALLED ON U. S. GEORGIA.

boiler, though there are many hundred thousands of horsepower in service, and many have been in continuous service six years. With this boiler there are no easily damaged parts of the casing near the bilges, hence there is no corrosion to the casing. The casing is made in removable sections, and no part of the casing or boiler front supports any part of the pressure parts. The boiler can be completely stripped, with all the pressure parts and piping connections in place, and this can be done without cutting any rivets, and the casing can be replaced without the need of any new material except such as may have given away, but none of the parts have to be broken or damaged in any way in order to take the casing off. Furthermore, any defect in the casing can be easily seen, so that it can be made good before it is extensive. The accessibility of all parts of the boiler is such that any one can be removed with but very slight or no disturbance of any other part, and such removal can be accomplished by the ordinary fire-room force. Thus a side-box, a mud-drum or a header can be taken out and replaced, the side-box in a few hours, the header or mud-drum in a couple of days, by the ship's own force and without any but ordinary boiler makers' tools.

The only seams on a Babcock & Wilcox boiler are on the steam drum; they have never been known to leak, and if by chance they should, the leak is readily seen and can easily be

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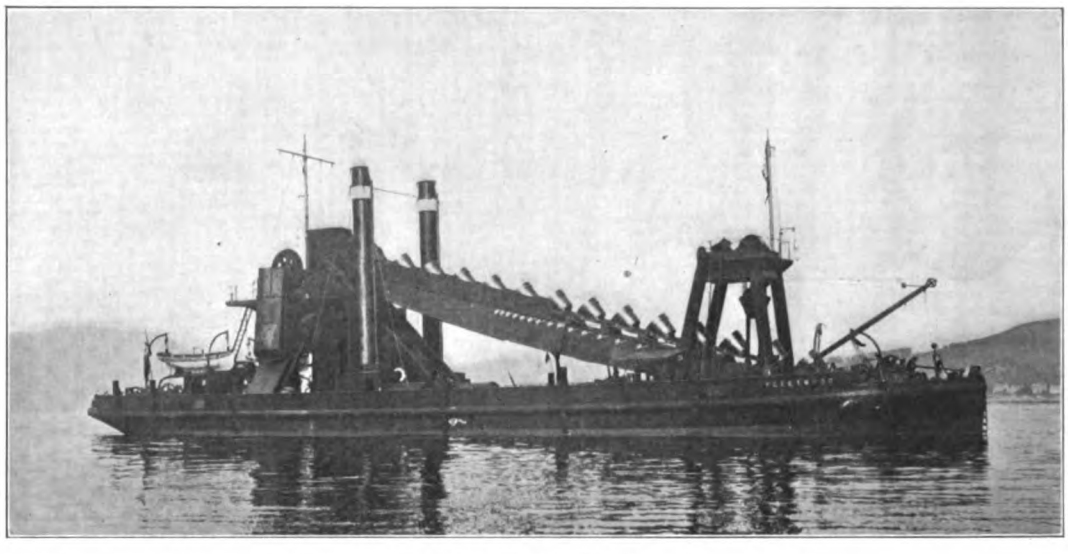
calked. In the case of express boilers, seams have often to be placed where it is difficult to calk them. Retubing or removal of a considerable number of tubes means an almost complete dismantling of the casing and usually the renewal of many parts that are damaged in the process of removal.

SAVING OF WEIGHT BY USING EXPRESS BOILERS.

The weight saved in express boilers has to be paid for, and it is paid for, as has been shown, in the excessive cost of repairs to these boilers and the difficulty encountered in renewals of various parts. (2) In the lack of economy in continuous, long steaming, due principally to lack of good baffling and the collection of soot, which cannot be effectively removed while the boiler is in use. (3) In the difficulties experienced when such boilers are called upon to use anything but thoroughly fresh and clean water, and the danger of leaks and tube failure where even slight deposits of salt are met with. (4) In the inability to make good slight defects as they are noticed, so that the boilers cannot be always in the best shape with the vessel in active service.

These conditions would bring out the question of whether the increased advantages in boilers of the Babcock & Wilcox type are really worth the increased weight and cost over express boilers. On a battleship the boiler weights are about 2½ percent of the total weight of the ship. By using some type of express boilers this weight might be reduced about three-fourths of 1 percent of the total weight of the vessel. On the score of weight saving it seems that this small extra weight, about 100 to 150 tons in our largest battleships, is well applied when the superior advantages are considered. As to first cost, some express boilers capable of doing the same work may be installed for about 20 percent less, but this difference is easily made up in one or two years' repair bills, or a couple of years' increased economy of coal consumption, to say nothing of the increased military efficiency of being always ready for service.

The adoption of a light express boiler, or one of a less reliable, economical or durable type than the one which has thoroughly demonstrated its advantages would seem to be a decidedly backward step, and one that sacrifices military efficiency and preparedness to temporary expediency. It may be urged that foreign navies have, to a considerable extent, used express boilers on their battleships, and that, therefore, this move should be followed, but in answer to this it may be stated that the German navy, or at least its battleships, do little extended cruising, and they never have had in their navy a boiler that approaches the complete answer to practical naval requirements of that developed in our service, and though the British navy does use large, straight-tube express boilers on some of its battleships, the larger portion of its recent installations consists of the English type of Babcock & Wilcox. Good express boilers have their field in torpedo craft and fast scout vessels, where economy, durability and reliability have to be sacrificed in order to get the weight for the necessary power. In large vessels of the fighting line, where the boiler weights are only about 2 percent of the total weight, this sacrifice is not necessary, and any step tending toward it would appear most unwise.



BUCKET DREDGER FLEETWOOD.

THE BUCKET DREDGER FLEETWOOD.

This vessel is the largest and most powerful bucket dredger owned by the Lancashire & Yorkshire and London & North-Western Joint Railway Companies. She is of the bow-well, center-bucket ladder type; length, 172 feet; breadth, 36 feet 6 inches; depth, 12 feet molded, and she is capable of raising 900 tons per hour. The vessel is built to Lloyd's highest class. The bucket ladder and box framings for supporting the chain of buckets and dredging gear have been constructed of the best class of girder work, all put together and efficiently connected with steel rivets closed by hydraulic pressure.

Side shoots are arranged for discharging the dredged material over either side of the vessel into hopper barges, the lifting and lowering of each shoot being worked by an independent engine. The regulation of the spoil to either side of the vessel is controlled by a strong, flat valve door, fixed at the apex of the shoots and worked by a gear from the main deck.

Separate accommodation is provided under the deck for the captain, engineers, crew and laddermen. The living quarters are well fitted up and well lighted and ventilated.

Steering gear is fitted on the bridge, which is placed on the highest point of the dredger at the top of the main gear framing. A complete installation of electric light is fitted throughout.

Heavy elm beltings are fitted all round the vessel, also strong, vertical fenders at intervals, to take the wear of the barges lying alongside.

The bucket ladder is suspended independently of the upper tumbler shaft. The main engines, which are employed for either propelling the vessel or driving the dredging gear, consist of one set of the triple-expansion, surface-condensing,

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inverted direct-acting type, having three cranks, and capable of developing 700 indicated horsepower. Steam reversing gear is fitted, also auxiliaries embodying all the latest improvements. Steam is supplied from two cylindrical return multitubular boilers, constructed under Lloyd's special survey.

three at the stern of the vessel, for manipulating the mooring chains and holding the dredger up to its work. Each winch is driven by a two-cylinder engine. The dredger is capable of a speed of 7 knots. She has a very complete outfit of stores and spare gear. The builders were Ferguson Bros., Port-Glasgow.

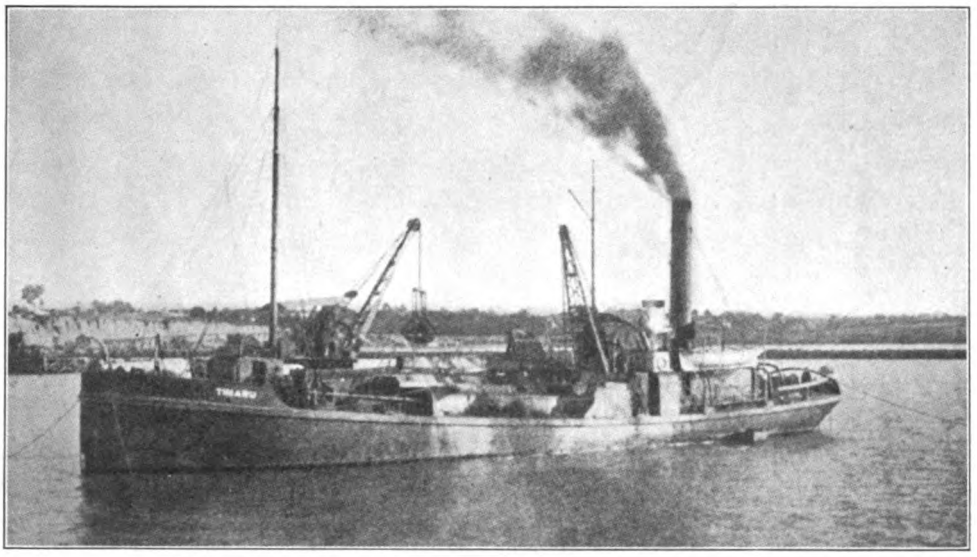

FIG. 1.—A STEAM HOPPER BARGE, FITTED WITH TWO KINGSTON DREDGING MACHINES.

The dredging machinery is of massive design. The gearing is arranged to work the buckets at two different speeds, according to the nature of material being dredged. All wheels, pinions, clutches, tumblers and bucket backs are of cast steel. The upper tumbler shaft is driven by a friction spur wheel of large diameter and capable of being adjusted to convey the necessary power to the buckets, according to the hardness of material being worked. The hoisting gear for the bucket ladder consists of a heavy wire-rope tackle, working in upper

KINGSTON DREDGING MACHINES.

The Kingston dredging apparatus, manufactured by Messrs. Rose, Downs & Thompson, Ltd., Hull and London, is a self-contained piece of machinery which can be mounted on a barge or float or on a self-propelled hopper barge for dredging operations to be carried out at a great depth below the water level or in inaccessible places around quays and docks.

Fig. 3 shows the apparatus complete with boiler installed on

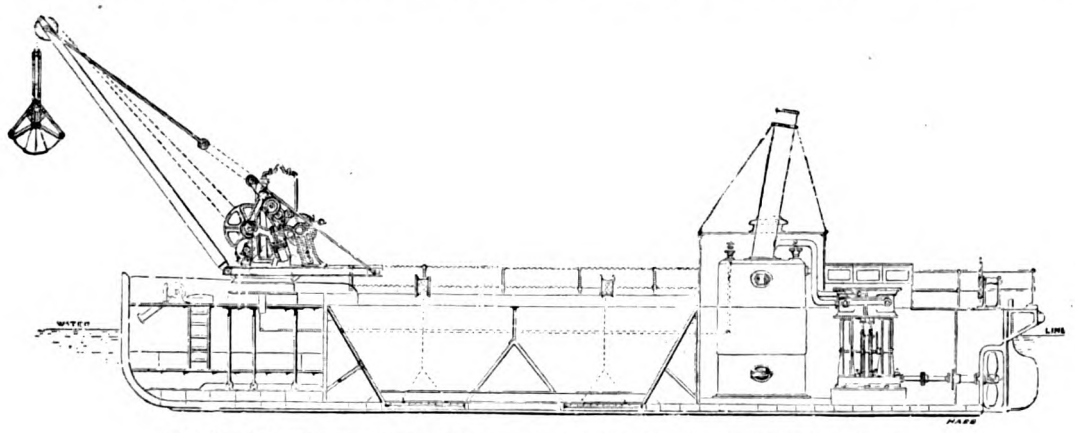

FIG. 2.—KINGSTON DREDGING APPARATUS ON A SMALL SELF-PROPELLED HOPPER BARGE.

and lower sheave blocks suspended from a cross-head fixed on a box-framing structure built into the hull at the forward end of the vessel, the lower sheave blocks are connected to the bucket ladder by strong forged side rods, the wire rope is wound on a large, grooved barrel, driven by gearing from a double-cylinder engine, all placed under deck. The wheels and handles for working this gear are placed on deck, under the control of the dredging master. The dredging buckets and links are of a specially strong design, each bucket having a capacity of 21 cubic feet; the connecting pins for the bucket chain are of manganese steel. A large crane is fitted on deck for overhauling buckets and links and for general purposes.

Six powerful steam winches are fitted, three at the bow and

an ordinary wooden barge not hoppered, while Fig. 2 shows the apparatus installed on a small self-propelling hopper barge. In this case steam for the dredging machinery is supplied by the main boiler of the barge. This class of machine is designed to convey its own spoil, and the particular one illustrated is capable of carrying 125 tons of spoil at a speed of 6 knots. Two or more machines can be mounted on one hopper, as shown in Fig. 1, thus making a very compact harbor-dredging plant, capable of giving a daily output up to 4,000 tons.

The steam hopper barge shown in Fig. 1 has separate propelling engines and boiler, and two Kingston dredging machines fixed fore and aft of the hopper well. A complete

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plant of this description can be supplied capable of a daily output from 2,000 to 5,000 tons.

In the construction of the Kingston dredgers no sliding counterweights are used to check the descent of the grab bucket. In ordinary types of similar machines the bucket is supported by two chains—the closing or hoisting chain, and the opening chain, the opening chain being held in tension while the bucket is lowered, and is capable of being stopped to allow the dredgings to be discharged, which is done by allowing the entire weight of the bucket to come upon the

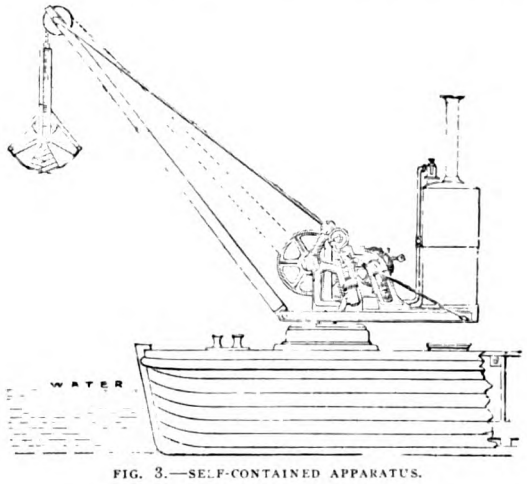

FIG. 3.—SELF-CONTAINED APPARATUS.

opening chain. This chain is usually connected by a series of sheaves to a weight moving against a vertical slide beside the boiler. As the grab is lowered this weight is raised, thus keeping the grab open by the tension on the chain. In the Kingston dredgers the opening chain is led to an auxiliary winch, so that when the grab is allowed to run out there is no counterweight tending to stop it, and the full energy of the falling bucket is employed in embedding itself in the material to be lifted.

The Lord Desborough.

The largest dredger that has been built on the Clyde, and also one of the largest dredging vessels afloat, is the *Lord Desborough,* 330 feet long, 54 feet 6 inches beam and 23 feet draft. She is fitted with double suction pipes, arranged to ship inboard, and is capable of raising 4,500 tons of sand per hour from a depth of 70 feet below the water level. The navigating and pipe-maneuvering bridges are placed forward of the hopper, while the chart room and steering house are on the upper and lower bridges, respectively. An accommodation gangway leads from the lower bridge to the engine casing, and on this gangway the gearing for working the lander doors, wash-out valves and hopper valves is arranged. Officers' accommodations are arranged aft of the machinery space, including a special suite of rooms for the superintending engineer. The crew's quarters are forward of the hopper.

The propelling and pumping engines, which were constructed by the builders, are of the triple-expansion type, using steam at a working pressure of 180 pounds per square inch. Steam is supplied by three multi-tubular boilers, each 15 feet in diameter.

The vessel has the following auxiliaries: Three sets of Weir's pumps, one Weir's evaporator and feed heater, four Gwynne's centrifugal pumps, a Kirkcaldy's distiller and pump, also a separate duplex for water supply to the sand pumps. Electric light is fitted throughout. The telegraphs are by Messrs. Chadburn, and consist of seven transmitters and six indicators. The pipe-maneuvering winches are of massive design, each having four barrels and weighing about 20 tons.

The vessel was constructed by Ferguson Bros., Port-Glasgow, under the direction of A. G. Lyster, of Liverpool, assisted by Messrs. H. West & Sons, Liverpool.

CURTIS TURBINES FOR THE NORTH DAKOTA.

Fig. 4 is a vertical section of one of the Curtis turbines now being built by the Fore River Shipbuilding Company, Quincy, Mass., for installation in the battleship *North Dakota.* The *North Dakota* is designed for a normal displacement of 20,000 tons, and requires for a speed of 21 knots approximately 25,000 horsepower. This is to be supplied by two Curtis marine reversible turbines, each of about 12,500 horsepower, driving twin screws. The turbines are to be operated at 245 revolutions per minute at full speed, with a steam pressure of

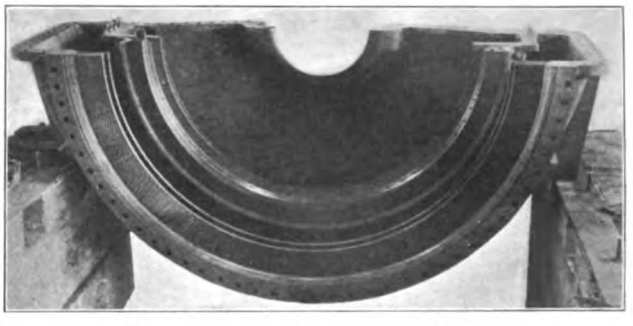

FIG. 1.—LOWER PORTION OF EXHAUST END CASING.

265 pounds per square inch in the steam chest and 28 inches vacuum in the exhaust shell. Each turbine is 144 inches pitch diameter and 22 feet 6 inches long center to center of the main bearings. The expansion of the steam is divided into nine stages in the ahead turbines and two stages in the reverse turbines.

The turbine consists of a cast iron cylindrical casing, divided by dished cast iron diaphragms into the requisite number of compartments or stages. In each compartment, or stage, except the first and the last four, there is a separate wheel, which carries on its periphery three rows of moving buckets. In the first stage there are four rows of moving buckets on the wheel, since the greater energy drop in this stage produces a greater velocity of the steam jet from the nozzles, which requires more rows of buckets to properly absorb the energy at the bucket

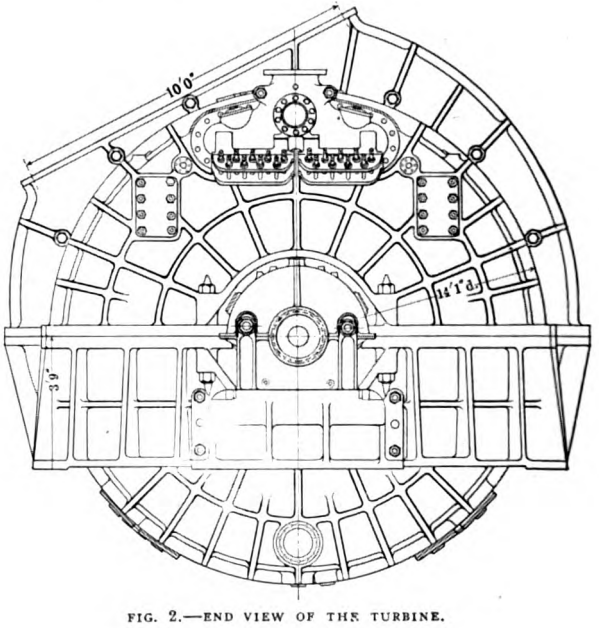

FIG. 2.—END VIEW OF THE TURBINE.

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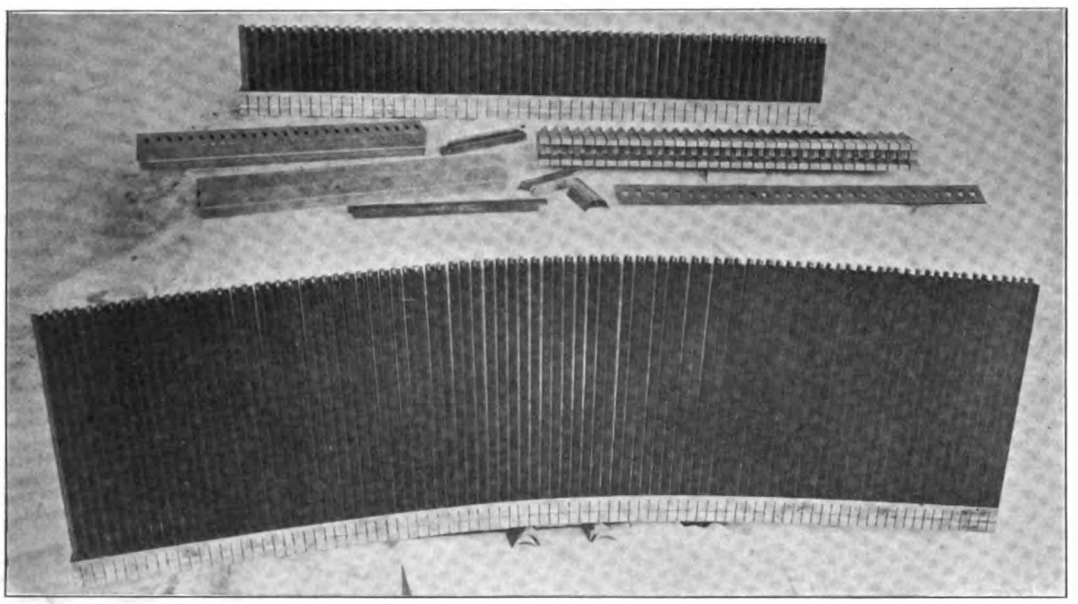

FIG. 3.—DETAILS OF BLADING.

speed used. One-fourth of the available energy of the steam is expended in the first stage and thirty-three seconds in each of the other stages. This is done in order to keep the pressure in the shell as low as possible. It requires, however, that the first-stage nozzle shall be of the expanding type, while all the other nozzles are of the parallel-flow type. The moving buckets for the sixth, seventh, eighth and ninth stages are all mounted on a single drum, there being three rows of buckets to each stage. The wheels and drum are all mounted on a hollow steel shaft, carried by self-alining bearings at either end of the turbine casing. Where the shaft passes through the diaphragms which divide the turbine into stages they are provided with bronze bushings having a small clearance, thus preventing appreciable steam leakage from one stage to the other. Where the shaft passes out through the ends of the casing it is provided with carbon stuffing-boxes, which prevent steam leaking out at the head end or air leaking in at the back end where a vacuum exists. The stuffing-boxes are supplied with steam in the space between the carbon packing, to prevent air leakage.

The reverse wheels are mounted in the after end of the casing, and under ordinary conditions, when the turbine is running ahead, they are in a vacuum, and, therefore, do not waste power by steam friction. Cast steel steam chests for

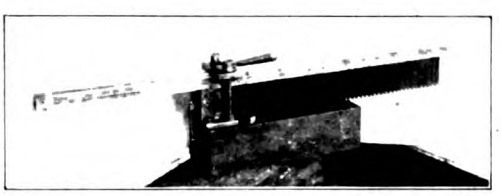

FIG. 5.—RIVETING JACK.

ahead and astern running are attached to the front and back casing heads, as shown, and are flanged for main steam pipes 13½ inches in diameter. The exhaust is through a rectangular opening 4 feet by 10 feet in the top of the casing at one side of the center line.

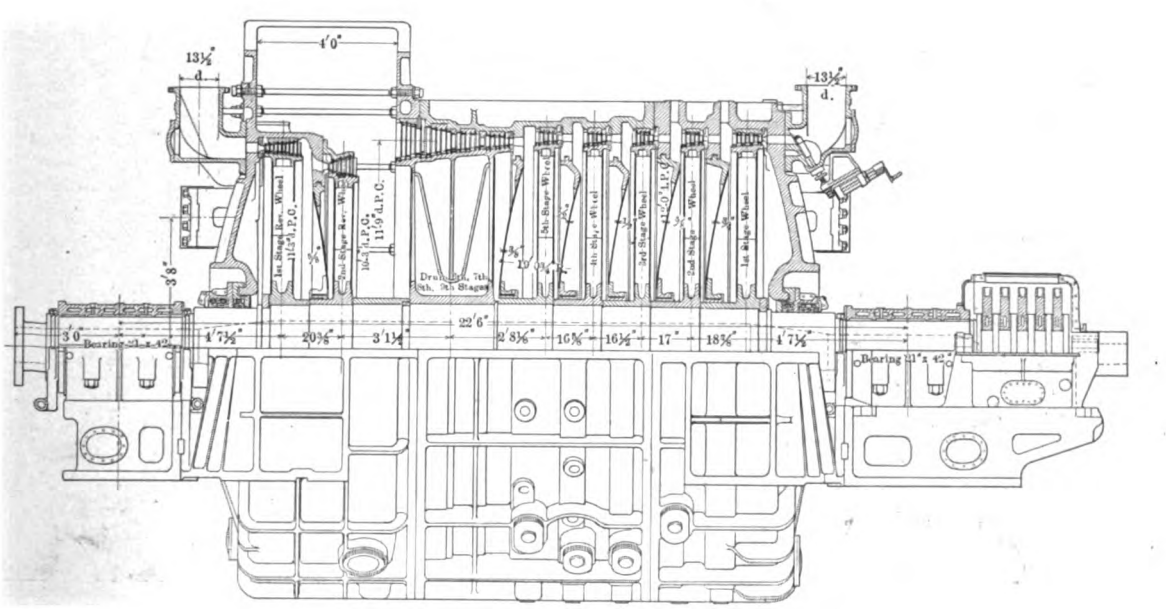

FIG. 4.—SECTION OF CURTIS TURBINE FOR THE NORTH DAKOTA.

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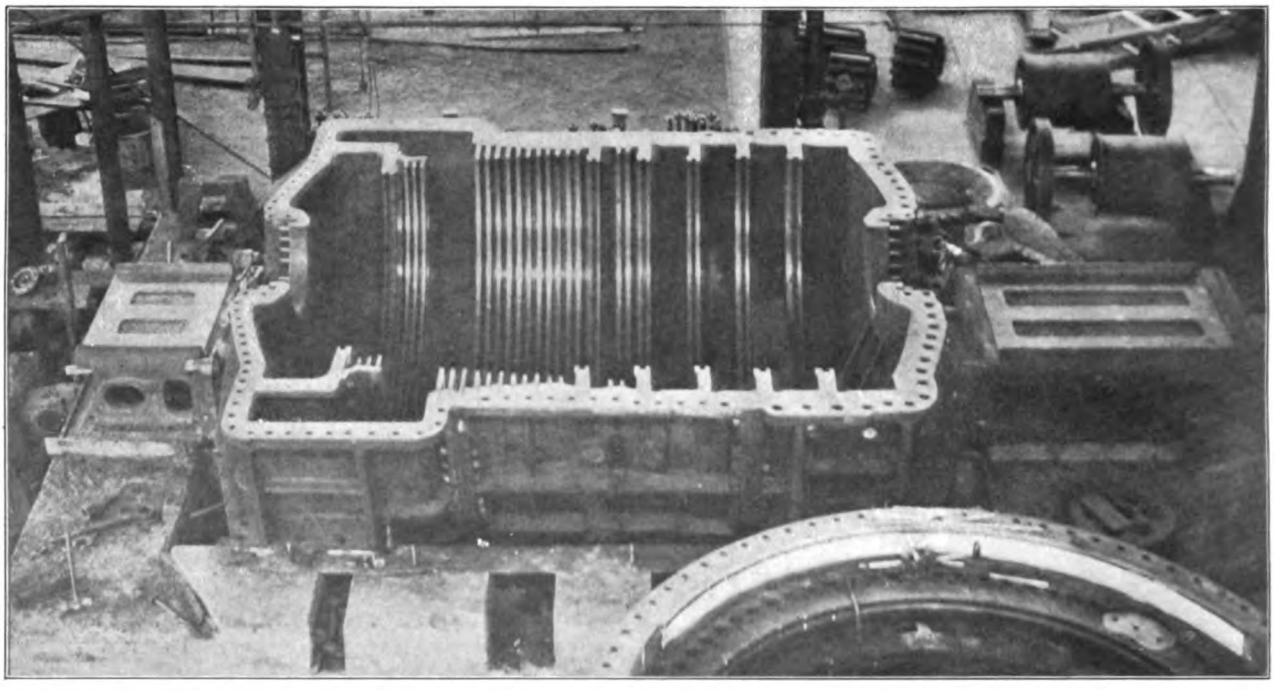

FIG. 6.—INTERIOR OF CASING.

A regular marine thrust bearing is attached to the forward end of the turbine shaft, the thrust block forming an extension of the forward main bearing. In addition to taking any unbalanced thrust which may occur, this bearing also maintains the proper axial position of the rotor, so that the axial clearance of the blades is correct. This clearance is about 1/10 inch on the first wheel, and increases as the size of the blades increases. The thrust bearing is placed at the forward end so that any unequal expansion of the shaft and casing will be allowed for at the after end, where the clearance is largest. The axial clearance is ample to allow for all unequal heat expansion that may occur and any mechanical irregularities, and leaves sufficient leeway for adjustments. Small clearances, both axial and radial, are unnecessary in the Curtis turbine, since the steam pressure on both sides of the wheels in each stage or compartment is uniform. Therefore, there is no tendency for leakage around the blades, and the clearance can be made as large as desired for proper mechanical construction. The only limit to the axial clearance or the distance between the edges of the blades is the

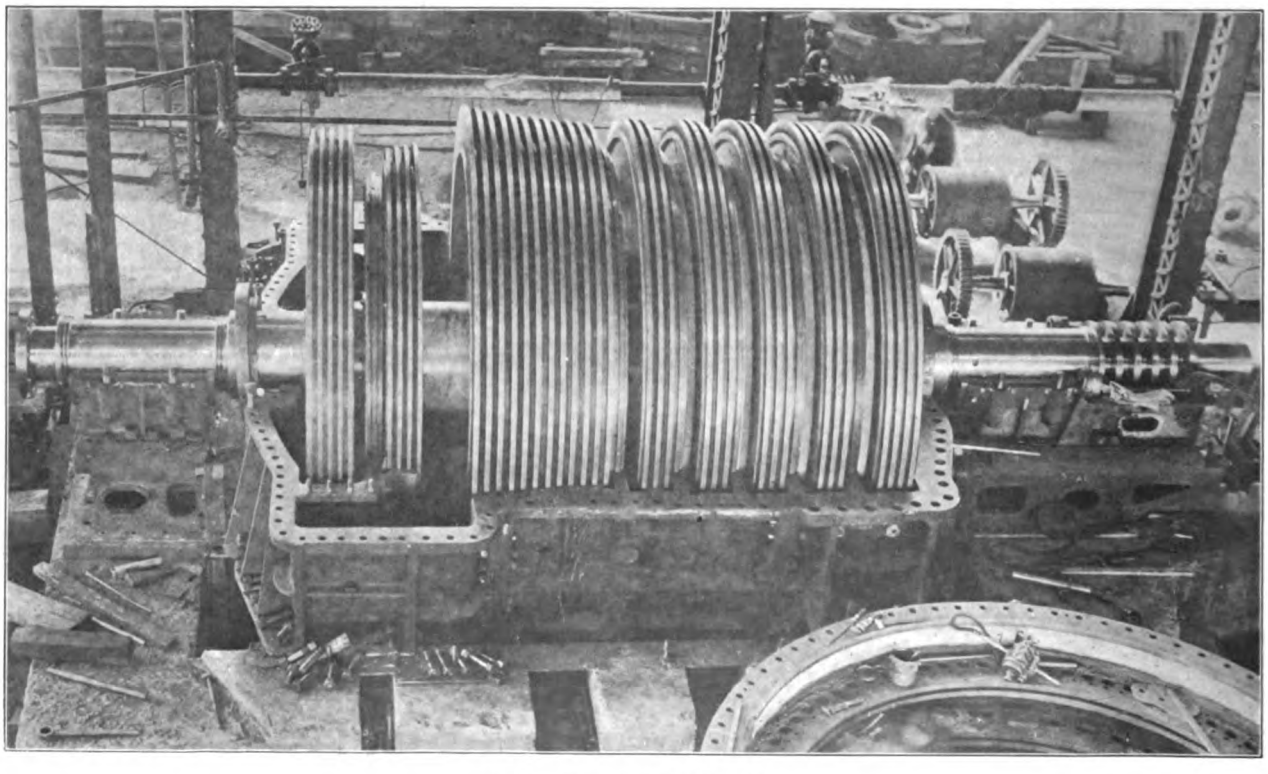

FIG. 7.—ROTOR IN PLACE IN CASING.

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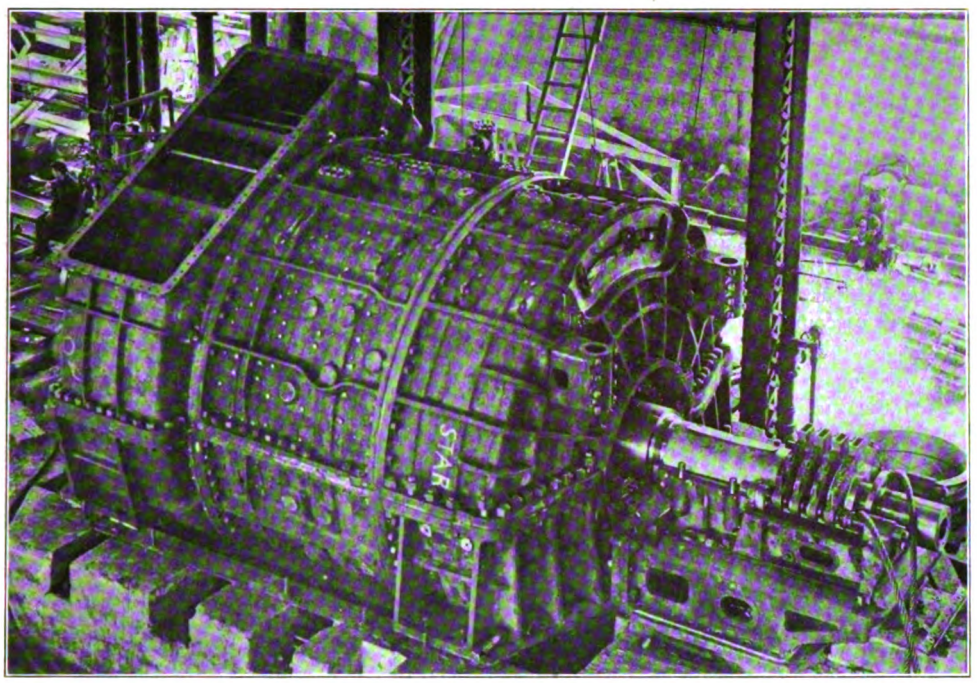

FIG. 8.—TURBINE ASSEMBLED IN BUILDER'S SHOP.

slight disturbance of the jet, which occurs at some distance from a nozzle or guide blade.

The steam pressure at the forward end of the drum approximately balances the thrust of the propeller, so that the thrust bearing is only required to take the resulting unbalanced thrust, which is comparatively small. The pressure distribution is proportioned to the area of the front of the drum to obtain this result.

A new form of turbine blading has been developed by the Fore River Shipbuilding Company, which is being used in the construction of the turbines for the *North Dakota*. The blades themselves, of which some 90,000 are required for both turbines, are of special bronze, accurately formed to the required shape by being extruded through a die. This stock is manufactured by a brass manufacturing firm in Connecticut for the special needs of turbine blades. These blades are cut to the required lengths, and the ends are milled to enter a steel channel-shaped base on one end and thin steel strips, called shrouds, on the other end. Details of the blades, channel-shaped bases and shrouds are shown in Fig. 3, as well as a section of blading which has been assembled.

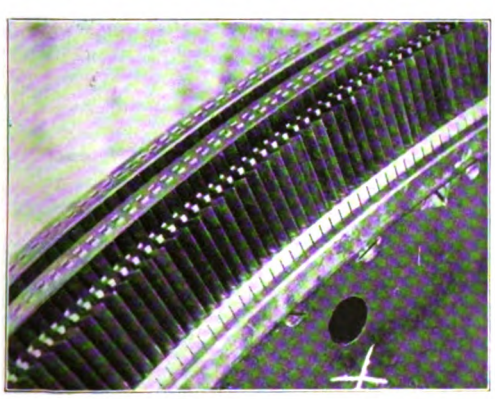

FIG. 9.—BLADING IN PLACE ON WHEE .

The channel-shaped bases are made in pairs on a duplex milling machine. This machine has a long table, which serves as a fixture to hold two sections of square stock, from which two backs are milled. After the bars have been milled they are placed in a special milling machine, on which a shallow V-shaped groove is milled in each side of the base. These grooves are for the purpose of fastening the bases to the rotor wheels into which they are later calked.

After the channel-shaped bases have been formed, the blades are riveted in place. This riveting operation is done by hand in a special riveting fixture or jack, shown in Fig. 5. A block is provided with a clamping jaw, so arranged that an individual blade will be grasped and held firmly in a vertical position. A strap clamp at the same time holds the base piece in its proper relation to this blade. When both blade and back are thus clamped in proper relationship one to the other the riveting is quickly and easily done. Various sizes of these

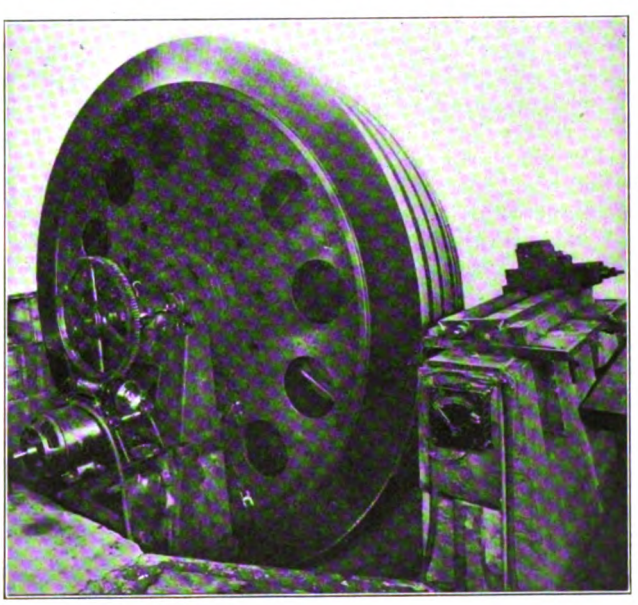

FIG. 10.—CALKING BLADING IN PLACE.

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jacks are necessary, because the blades are not all of the same length.

After the blades have been riveted in place, the channel-shaped bases are placed on a special machine, where a series of cuts or slits is made through the legs of the channel-shaped piece. This is done in order to give the section of blading sufficient flexibility, so that the bases may be shaped to the positions which they are to occupy in both wheels and casings. This is a feature which has been largely responsible for the success of this new system of blading. The amount of flexibility gained in this way is shown by the section of blading in the lower part of the photograph, Fig. 3. This section has been supported at the center, and, as seen, conforms itself into a curve of comparatively short radius merely by the action of its own weight.

After the various sections of both moving and stationary blades are completed the turbine wheels are mounted in a horizontal position in a special machine for the operation of calking the blading into place and attaching the shrouding. The turbine wheels themselves are built up of circular discs of boiler plates in which lightening holes are cut, as shown in Fig. 10. To these discs are riveted and screwed cast steel rims. In the cast steel rims are turned a series of grooves of the proper size to receive the legs of the channel-shaped bases of the sections of blading. These sections of blading are placed in position, and the steel rim is then calked or staked down into the V-shaped grooves milled in the sides of the channel legs, thus holding the blading firmly in position in the wheel. It is stated that in tests a pull of some 9,000 pounds is required in order to loosen the blade after it has been properly calked in position. This, it is claimed, is more than ample to resist any stresses to which a blade might be put.

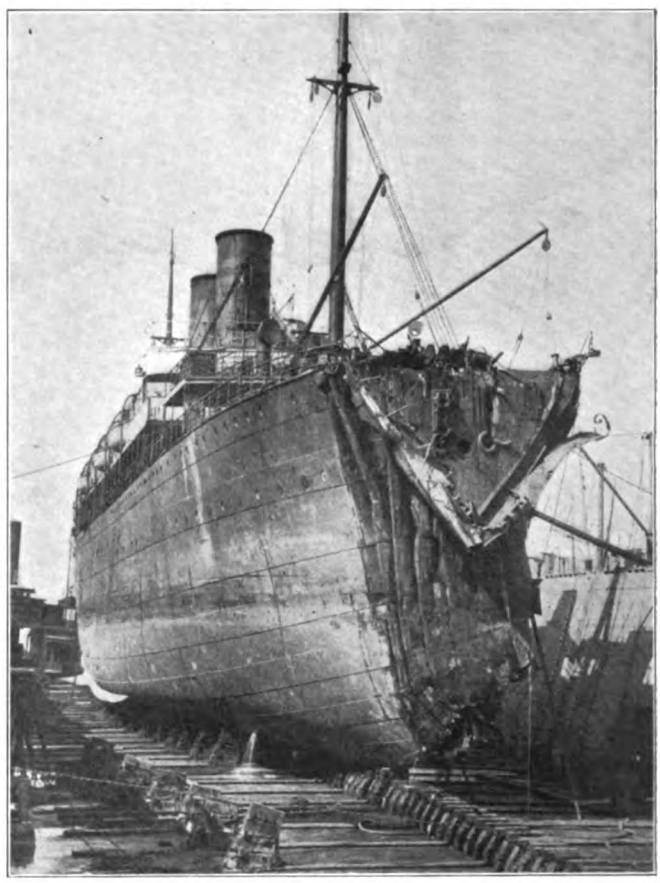
Fig. 10 shows the manner in which the blades are staked in position. In the part of the machine which has the appearance of a tool block is clamped a pneumatic hammer, in which a forked calking tool is placed. This tool straddles the blades and stakes over the edges of the rim into the grooves of the channel-shaped legs. The wheel itself is slowly rotated by power derived from the electric motor, shown in the illustration. At the same time the shrouding is placed in position over the milled outer ends of the blades, and the ends of the blades are securely riveted over. These various operations are clearly shown in Fig. 9, where three rows of blades are shown in place in the rim of a wheel; the ends of one set of blades are shown without the shroud in place; in the next row the shroud is in place, but the ends of the blades are not riveted over; while in the last row the ends of the blades are riveted over and the entire operation is complete.

The manner in which the stationary blades are secured in position is much the same as the moving blades. The sections of stationary blades are, however, fastened in place in the turbine casing by bolts. Fig. 1 shows the lower half of the exhaust casing with the blades in position, while the entire lower half of the turbine casing is shown in Fig. 6.

The steam is expanded in each stage through nozzles bolted to the diaphragm, as shown in the sectional drawing, Fig. 4. The diaphragms have steam port openings cast in them to allow the steam to pass through to the nozzles. The nozzles themselves are government bronze castings, cast in long, segmental shapes. The openings are cored in them and have a double taper. These nozzles, of course, must all be of an exact size, and have smooth surfaces. In earlier types of Curtis turbines this was accomplished by chipping and filing, which was a very expensive process. A special planing machine was, therefore, designed and built, by means of which this work is now done. As there are both right-hand and left-hand nozzles in a reversible turbine, it was necessary to incorporate in the machine facilities for planing either right-hand or left-hand nozzles.

REPAIRS TO THE FLORIDA.

The Italian Line steamship *Florida*, which sunk the *Republic* in collision off Nantucket, Jan. 23, was docked for repairs at the yards of the Morse Dry Dock & Repair Company, Brooklyn, N. Y. As shown by the photograph the bow of the *Florida* was crumpled up for a distance of about 40 feet aft of the stem. After the deck fittings had been removed the shell plating on each side of the vessel was cut down to the water's edge, about 2 feet back from the damaged portion, with pneumatic tools. After the waterline was reached the ship was placed in drydock, stern first. The water was then pumped out, and a 200-ton Monarch crane floated up to the end of the dock and the chains were made fast to the damaged bow.



THE FLORIDA IN DRY DOCK, SHOWING DAMAGED BOW.

The shell was then cut down through the keel on both sides, and the bow lifted bodily by the crane and taken away. The ship was then lowered off the dock, turned around and placed bow in, in order to bring the bow close to the shops and tools. The various strakes of plating were then cut back to the butts, and the new stem, frames and plates placed in position. The ship was then riveted to above the waterline, and lowered off the dock when repairs were completed.

This work was carried out with great facility, as the ship was delivered ready for cargo within twenty-four days. The steel stem, which was cast by the New Jersey Steel Company, Rahway, N. J., was delivered in four days after the pattern was received, which is one of the quickest jobs of steel casting which has come to our notice.

A steel, single-screw steamer, 195.5 feet long, with a beam of 43 feet and depth of hold of 19½ feet, is in service on the Great Lakes for salvage and repair of wrecked vessels. The vessel is fitted with a towing machine, derrick and grab bucket, diving apparatus and an exceptionally large pumping plant.

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A SUCTION CUTTER DISCHARGING DREDGE FOR INDIA.

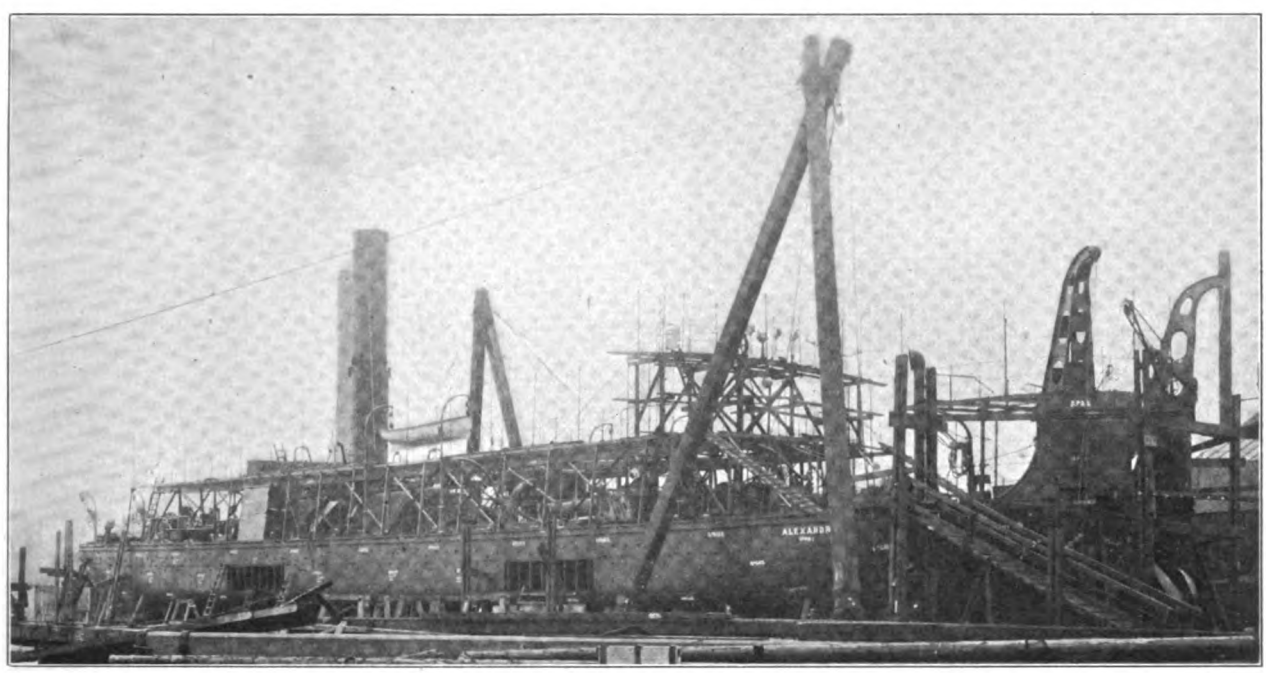
Messrs. William Simons & Company, Ltd., of Renfrew, have completed and shipped, to the order of the Secretary of State for India, a specially designed hydraulic dredge for the improvement of the waterways and for canal construction in the Bengal province. The dredger can open up a canal and deposit the dredged spoil on or over the canal banks. The vessel, which is named the *Alexandra*, is of the shallow draft type, with the hull structure arranged and suitably strengthened to resist machinery vibration when the full engine power is being exerted. The dimensions of the hull are 205 feet by 40 feet by 19 feet.

The suction pipe is carried by framework in a well forward. There is also attached to this frame the shafting and gearing for driving a Robinson's rotary cutter, arranged to work in advance of the suction orifice for pulverizing and disintegrating clayey material, which would otherwise resist the action of the suction pump. The suction frame is provided with a system of high-pressure water jets, for disintegrating compact sand which may not be resistant enough to call for the employment of the rotary cutter. Water for the jets is supplied from two special centrifugal pumps, in series, driven by an enclosed high-speed compound engine. The cutter is driven by bevel and spur gearing from an independent two-cylinder compound engine, placed on deck close to the well. Made of steel throughout, the cutter is, as stated, of Robinson's rotary type. It is designed to dredge hard clay or other difficult substance other than stones or rock, and is sufficiently strong to encounter immovable resistances without breaking. Should material, such as rock, be encountered, no breakage will occur; the engines will be simply brought to a stop, the working parts being sufficiently strong to take the strain.

The suction frame is controlled by independent hoisting gear, driven by two-cylinder engines, and when not at work, or when the dredge is under propulsion, the frame and the piping and cutter are hoisted clear above the water level. For purposes of mooring while at work the dredge has an arrangement of horns at the bow. These horns carry long, wire-rope blocks and tackle, which connect with tube mooring piles sunk under pressure in the sandy bottom of the canal or river, just as circumstances or the site of operations may require.

A centrifugal sand suction pump is situated a little forward of amidships. It is specially constructed with wide spaces to permit of the passage of large pieces of debris. All surfaces liable to the erosive action of the sand are fitted with adjustable wearing pieces. The suction pump is driven by an independent set of vertical triple-expansion engines of 900 indicated horsepower. The pump delivers the material dredged direct through a floating pipe line 600 feet in length. The pipe line leaves the dredge at the stern, and here there is a special swiveling connection, so arranged that the pipe line can be connected directly aft or on either side of the dredge.

The floating pipe line consists of circular pontoons, each carrying a discharge pipe, the discharge pipes being coupled together by special flexible connections.



HYDRAULIC DREDGE, ALEXANDRA, UNDER CONSTRUCTION AT YARDS OF WM. SIMONS & CO., LTD.

The vessel has two sets of vertical triple-expansion surface-condensing engines, each driving a propeller having four blades. The engines and propellers are designed to develop sufficient power for propelling the dredger at a speed of 9 statute miles per hour. Steam is provided by two cylindrical multi-tubular steel boilers, constructed to Lloyd's requirements for 160 pounds working pressure, reducing valves being fitted to suit the requirements of the auxiliary engines.

One main condenser is provided to take steam from all the engines on board, the condenser having a complete outfit of steam-driven air and circulating pumps. The auxiliaries include a vertical, long-stroke feed pump for boiler supply, with automatic control gear; two vertical duplex general service and bilge pumps; two feed-water filters, each arranged so that the other can be overhauled when the dredger is at work, and an evaporator for providing fresh water. The vessel has also a complete electric light installation. There is a workshop on deck, equipped with a forge and a number of machine tools, so that, irrespective of the position of dredging operations, repairs may be speedily effected on board without recourse to workshops on shore. Telegraphs are fitted from the operating bridge of the dredger to all working parts, so that one man standing on the bridge can control all operations.

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THE SIR HARRY BULLARD.

The twin-screw, combined barge-loading and hopper dredger, *Sir Harry Bullard,* recently launched from Messrs. Ferguson Bros.' yard at Port-Glasgow, has carried out her dredging and speed trials on the Firth of Clyde. The vessel loaded her hopper in forty-five minutes at Port-Glasgow harbor, and afterwards proceeded to the measured mile, where, on four runs with and against the tide, a mean speed of about 8 knots was obtained, being half a knot in excess of the contract.

The vessel has been built to the order of the Great Yarmouth Port and Haven Commissioners, under the direction of Messrs. Coode, Son & Matthews. Her dimensions are:

Length	172 feet.
Breadth	31 feet.
Depth, molded	13 feet.

The dredger is of the bow-well type, arranged to cut her own flotation, having a central hopper. Discharging shoots

TWIN SCREW COMBINED BARGE LOADING AND HOPPER DREDGER.

are fitted for self or barge loading; the navigating bridge is placed on top of the framing, and is fitted with a steam steering gear, a Lord Kelvin compass, and Chadburn's repeating telegraph.

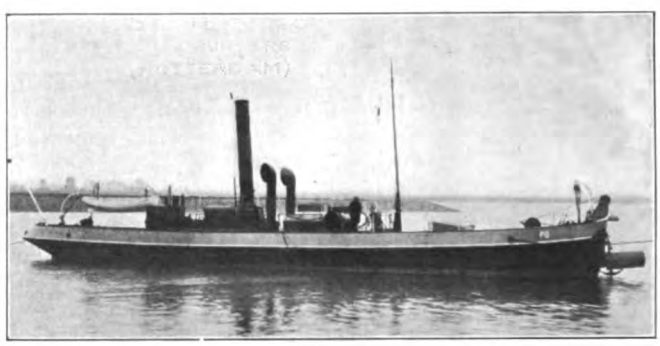
The machinery consists of two sets of compound surface-condensing vertical engines of 800 indicated horsepower, both engines exhausting into a large condenser, having an independent circulating pump and Edwards' air pumps. Steam is supplied by two marine tubular boilers fitted with corrugated furnaces.

Powerful triple-barrel, double-cylinder mooring winches are fitted at the bow and stern for manipulating the mooring chains, Chadburn's telegraphs being fitted to transmit orders to these winches. The hopper doors are controlled by friction winches of the latest type, each winch having an independent engine, the worm wheels being of gunmetal and the barrels of cast steel.

The gear for raising the bucket ladder is of massive design, capable of handling the ladder with steam at 50 pounds pressure, the working pressure being 120 pounds per square inch; compound brakes are fitted, also a double-cylinder engine, complete with governor and controlling levers. The spur and bevel wheels throughout the vessel are of cast steel, the upper tumbler shaft having double-friction spur wheels of large diameter. The buckets are of a design to facilitate the free discharge of clay, the backs are of cast steel, the bodies of steel plates and the wearing lips hard steel forgings, and are riveted by hydraulic power. The links and pins are of special quality steel for hard wear.

The Suction and Force Pump Dredger Po.

The *Po,* built by Werf Gusto, Shiedam, Holland, in 1908, to the order of the Italian Government, is a seagoing twin-screw suction and force-pump dredger, designed for deepening the river Po. The principal dimensions are: Length, 98 feet 5



THE PO.

inches; breadth, 19 feet 7 inches; depth, 7 feet 3 inches; capacity, 555 cubic yards an hour. She is capable of dredging material from a depth of 23 feet. The spoils can be forced away to a distance of 330 feet through a floating conduit resting on small pontoons fitted with anchors. This conduit has been specially designed for resisting the strong currents which prevail in the River Po.

SUCTION DREDGER FOR NEW ZEALAND.

In the yards of William Simons & Company, Ltd., Renfrew, Clyde, a large twin-screw, stern-well, combined bucket suction and discharging dredger, named the *Mawhera,* has been built for the Greymouth Harbor Board, New Zealand. The dredger was launched with all its machinery on board complete and ready for work.

The hull and machinery were built to Lloyd's highest class. The bucket and pump dredging outfit embodies all the most modern improvements, and is provided with all the appliances necessary for reclaiming land. The bucket ladder is arranged so that the bucket can dredge close up to quay walls, and also cut the dredger's own flotation. The discharging pump is arranged to receive and deliver, through a long length of floating and shore pipes, the material dredged by the suction pump or buckets.

Propulsion is by means of two sets of triple-expansion, surface-condensing engines, each driving its own propeller. Steam is supplied from two steel boilers, constructed to Lloyd's and Board of Trade requirements, for a working pressure of 160 pounds per square inch. The propelling engines are also arranged for driving the bucket chain at two different speeds, and the suction pump and discharging pump, either in conjunction with the buckets or separately, as required.

The auxiliary outfit includes independent automatic feed pumps, bilge pumps, service pumps, circulating pumps, condenser, feed heater and filter. The dredging machinery is of very massive design for dealing with hard material, and all parts of the gearing and bucket chain are of special hard and durable steel, to reduce wear and tear to a minimum. Independent steam hoist gears are provided, both for ladder and suction pipe. The mooring winches at the bow and stern are exceptionally strong.

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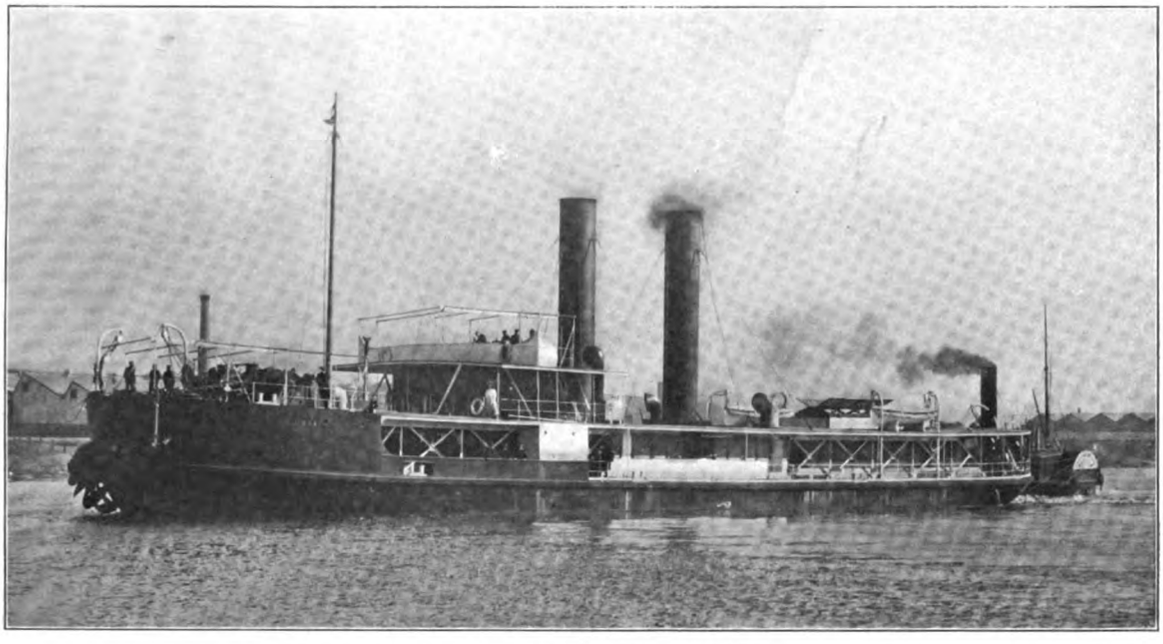
RECLAMATION DREDGERS FOR BOMBAY.

Messrs. William Simons & Company, Ltd., Renfrew, have just completed two extremely powerful suction pump and discharging dredgers, to the order of the Bombay Port Trust. The dredgers, which are named *Jinga* and *Kalu*, are each fitted with what is claimed to be the most powerful pumping plant afloat, designed to dredge 2,700 tons of material per hour, and discharge same through a floating pipe line, fitted with steel ball and socket joints and land pipes to a distance of upwards of 4,500 feet from the side of the dredger. These vessels will be employed upon an extensive reclamation scheme at Bombay, and have been constructed under the direction of Sir J. Wolfe Barry and Mr. A. J. Barry, M. M. Inst. C. E., consulting engineers in London to the Bombay Port Trust, and Mr. George Turner, resident inspecting engineer. It is estimated that by the operations of the two dredgers, under the present scheme alone, an addition of about 4½ percent will be made to the area of the city of Bombay.



THE JINGA, SHOWING ROTARY CUTTING GEAR.

Both dredgers will proceed to Bombay under their own steam, and for this purpose two sets of compound surface-condensing engines are provided, capable of driving the vessels at a speed of 8 knots. The pumping outfit consists of very large centrifugal suction and discharging pumps, directly coupled to triple expansion surface-condensing engines. A large condenser is fitted to take the exhaust steam from all engines on board. Steam is supplied from four very large cylindrical multi-tubular boilers, constructed to Lloyd's full requirements and fitted with Howden's patent forced draft. The boilers are specially designed for burning inferior Indian coal. A very full equipment of engine room auxiliaries is provided, including independent circulating pumps, independent automatic feed pumps, independent bilge and general service pump, feed heater, filter, evaporator, etc.

A spiral rotary cutter is fitted at the lower end of the suction frame, driven by steel spur gearing by a set of compound surface-condensing engines. The suction frame is controlled by independent steam hoisting gear. Bow and stern winches of particularly powerful construction, arranged for rapid handling of wire-rope moorings, and anchor cables are provided. The control of the dredger is centered on the operating bridge, on which are placed all telegraphs, speaking tubes and signals to the cutter engines, pump engines and stern winch, also the handles for controlling the frame hoisting gear and the bow winch. One man can thus control and direct all the operations of the dredger and the pipe line. The living accommodation and the general arrangements are all designed for a vessel working in a tropical climate, every attention having been given to light and ventilation.

The vessels are electrically lighted throughout, having a powerful searchlight for manipulating the dredger's pipe line when working at night. Telephone communication between the dredger and the end of the pipe line is also provided.

A GERMAN SUCTION DREDGER.

Suction dredges in which the soil is drawn up from the bottom by suction and then forced overboard are largely used at the present time, principally on account of the economy which can be effected by their use. This is due, first, to the small working expenses, which are considerably less than those required for a bucket dredger, and, second, on account of the cost of repairs, which is also less than in the case of a bucket dredger, where there are so many parts which are subject to hard wear and tear. These considerations, taken in connection with the first cost and depreciation, make the suction dredger an economical piece of apparatus.

In soft soil the suction of the pumps is sufficient to loosen the material and draw it through the suction pipes, while in hard material it is necessary to break up or cut the soil before it can be sucked up by the pumps.

The illustrations show a suction dredger built on this principle by the Gebrüder Sachsenberg A. G., in Rosslau, Germany, for the Gebrüder Goedhart A. G., Düsseldorf. This dredge has a capacity of 17,660 cubic feet per hour in hard material, with a dredging depth of 46 feet, and is capable of forcing the soil through a distance of 3,281 feet. The principal dimensions are: Length between perpendiculars, 149.8 feet; breadth over the frames, 26.25 feet; molded depth, 11.5 feet; draft in working condition about 7 feet.

The hull is built of mild steel to the highest class Germanischer Lloyd's, and where necessary, as in the machinery foundations, special reinforcement is provided. The vessel has a steel deck and also steel deck houses over the boiler and engine rooms, built up of plates and angles. On account of the opening for the suction pipe in the center of the vessel forward, there are really two intercostal keelsons. These divisional bulkheads, together with five transverse bulkheads,

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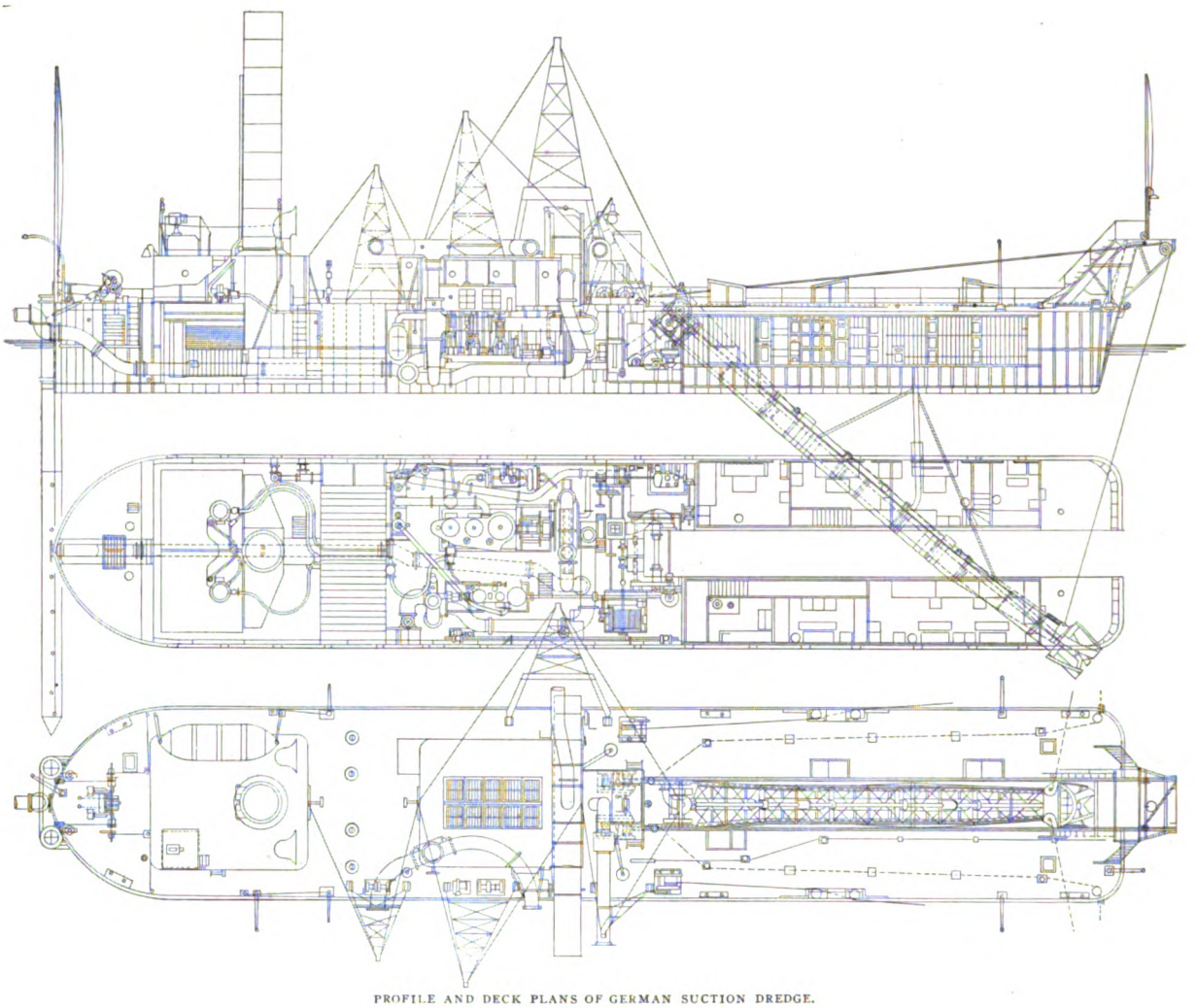
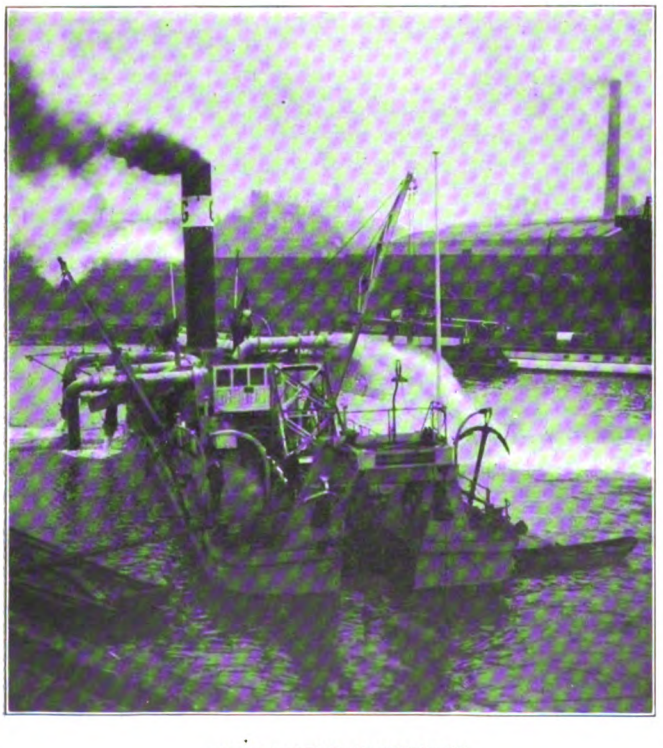


PROFILE AND DECK PLANS OF GERMAN SUCTION DREDGE.



GERMAN DREDGE IN OPERATION.

divide the hull into six watertight compartments. A double fender of oak, 11.8 by 5.9 inches, extends entirely around the hull, and is fastened to the shell by heavy angle bars. There are also vertical fenders of the same dimensions every fourth frame space.

In the living quarters, which are in the forward part of the vessel, there are cabins for the dredge master, one for the two chief engineers, one for the two second engineers, one for one assistant, one for four firemen, and one for the crew. There is also a galley, pantry, storeroom and chain locker in this part of the vessel.

The arrangement of the suction pipe, the windlass for operating it, and the cutting apparatus is shown in the plan and profile drawings. This pipe, when dredging at a maximum depth of 46 feet, has an inclination from the horizontal of about 42 degrees. Its construction consists essentially of two plate girders with the necessary cross and diagonal bracing of angle bars and plates. This pipe is movable about a horizontal axis, and is connected through a stuffing-box in the port longitudinal bulkhead to the pipe leading to the suction pump. The cutting apparatus at the end of the suction pipe is operated through bevel gears from one of the main engines of the dredge. The apparatus itself consists of five knives fastened in a cast steel head, the outer end of the knives being fastened to a five-armed or star-shaped casting, to afford strength and rigidity. The knives are 12.6 by 1.77 inches by 4.92 feet long.

The arrangement of the boilers, pumps and engines is clearly shown on the drawings. The suction pipe leads first

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to the suction pump, thence leading to the force or pressure pump. All the pumps are of the centrifugal type, and are direct connected to steam engines. The suction pump is built by Nagle & Kaemp A. G., Hamburg, and has a bucket wheel 90.55 inches in diameter fixed to a shaft 8.66 inches in diameter. The force pump, which is supplied by the same firm, has a bucket wheel 41.73 inches in diameter. The air and circulating pumps, the latter for the circulation of water in the condenser, are also direct connected to steam engines. The engine for driving the suction pump is of the triple-expansion, vertical type, with cylinders 16.14, 26.38, 40.55 inches in diameter and 19.69 inches stroke. At a speed of 220 revolutions per minute it is capable of developing 900 indicated horsepower.

The force pump is also connected to a triple-expansion, vertical engine, somewhat smaller than the other one. This engine has cylinders 11.81, 18.9, 29.53 inches in diameter with a stroke of 13 inches, and at 210 revolutions per minute develops 300 indicated horsepower. This engine also drives the shaft for operating the cutter. The air and circulating pumps are driven by a two-cylinder high-pressure steam engine.

Steam is generated at a pressure of 190 pounds per square inch in two cylindrical, return tubular boilers of the marine type, each boiler having 1,937 square feet of heating surface. The boilers are 11.5 feet long, 11.15 feet diameter, and each has two corrugated furnaces 45.28 inches mean diameter, as well as 200 ordinary tubes 3 inches outside diameter, No. 10, B. W. G., and sixty-four stay-tubes 3 inches outside diameter, No. 1, B. W. G. The feed and auxiliary pumps include one feed pump, one duplex steam pump, one injector, one hand pump, one ejector. There is also an evaporator and an oil separator. With the exception of the bilge pipe all pipes are of copper, and where necessary are provided with means for draining off the condensed water. All pipes leading outboard have stop valves. All steam and hot-water pipes are carefully lagged.

THE FRUHLING SYSTEM OF SUCTION DREDGING.*

In any attempt to improve the efficiency of the suction dredge an effort must be made not merely to loosen but also to secure the material by a mechanical cutting of the surface, and also to control the inrush of water at the suction pipe entrance. To achieve either of these results is to greatly improve the suction dredge. Otto Fruhling, of Braunschweig, Germany, a contractor, dredge operator and designer, has developed a new system of suction dredging which fulfills the above desiderata and possesses other features of great value.

His system consists of fitting a large inverted dipper-dredge bucket on the bottom end of the suction pipe to scrape up and collect the dredged material before the suction forces come into play. It was to be expected that the addition of the broad bucket head, with its ponderous weight and sharp cutting edge, would produce a greatly increased supply of sand and mud to the suction pump, but it was hardly anticipated that the action would be such as to completely bar the admission of the surplus water; yet such was found to be the case, and to such an extent as to require the fitting of pressure-water connections to the inside of the bucket head, so that sufficient water might be pumped in at will to liquefy the solid material and bring it to such a consistency as would enable the suction pumps to handle it. Small valves added to the head, permitting a certain flow of the surrounding water at the will of the operator, were also fitted.

In the interior of the scraper head, before the dredged material comes into range of the suction, it is forced into a mixing chamber, where the dredgings are reduced to a uniform consistency by the pressure water or by the mere admission of outside water. From the mixing chamber the material is drawn through the pumps and is discharged into the hopper.

The largest dredge of this type yet built is *Dredge VII.*, belonging to the German government and employed in widening and maintaining the approach channels through the Jade Estuary to the great North Sea naval station of Wilhelmshaven. This vessel (Fig. 1), built by F. Schichau, Elbing and Dantzic, Germany, will serve to illustrate the construction and operation of the Fruhling dredge. The principal dimensions of *Dredge VII.* are: Length, 265 feet; breadth, 48 feet; depth, 20 feet. There is one large hopper forward of the machinery space, with a total capacity of 2,000 cubic yards, provided with bottom doors for discharging the dredgings by dumping. The propelling and pumping machinery consists of four sets of triple-expansion engines, each unit of 500 indicated horsepower. These four units are arranged tandem, two on each bedplate, and drive twin screws. The two aftermost engines are coupled direct to the propeller shafts and two forward units to the suction pumps. When it is desired to exert full power (2,000 indicated horsepower) on the propellers, as when steaming at sea or to a dump with a load, a clutch mechanism connects the forward and after units on each bedplate. In dredging only the after pair of engines are used for propulsion, while a speed usually of from 4 to 5 knots over the ground is maintained, and the forward pair of engines drive the pumps. All four engines exhaust to a central condensing installation with separate air, feed and circulating pumps. The arrangement lends itself to great economy, the coal consumption working out at the surprising figure of 0.85 pounds per indicated horsepower per hour over long periods of work.

The suction pumps are two in number, each with a diameter of 5 feet 2 inches. When working in mud the speed of the pump is about 200 revolutions per minute, and when working in sand is 140, both figures, of course, being variable. The design of the pump is a very important element in the success of the Fruhling dredge, and it may be said, briefly, that the characteristic features are small diameter, high speed and small clearances.

The most striking features of the Fruhling dredge are the arrangement of the suction arm and the bucket head. In *Dredge No. VII.*, and in most other dredges of the type, the hull is cut in two by a narrow fore and aft channel or well, terminating just abaft the after pair of propelling engines. At the forward end of this well, at about the level of the waterline, a massive pillow-block on each side supports a pair of hollow trunnions, by which is supported the heavy bridge-girder frame, which carries the suction and pressure pipe and bears the stresses coming on to the dredging head. At the lower end of the girder is a huge pair of hinges, by which the bucket head is attached, so that it has a movement of rotation about a horizontal axis at right angles to the direction of the girder, to enable the cutting angle to be varied at will. The hinges are hollow, and through them the suction pipes enter the bucket. This latter is made of steel castings bolted together, and is 16 feet 6 inches broad by about 5 feet in depth. It has a cutting edge studded with hollow teeth, through which jets of pressure water can be ejected to help break up tough material. There are also baffle plates to reduce the size of the entrance, and a series of bars to form a grid and prevent the admission of undesirable objects.

The operation of the Fruhling dredge is briefly as follows: The heavy head is dragged over the bottom at a speed of 4 of 5 knots. It scrapes or plows off a strip as wide as itself, from 12 to 18 feet, and from 12 to 18 inches in depth. The material as it is plowed up is forced into the head by the pressure of the scooping action. Here it is kneaded, mixed and liquefied, as may be found necessary, and finally is sucked up by the pump. The action is quite continuous, but is in

* Abstract from an article by John Reid in "Engineering News."

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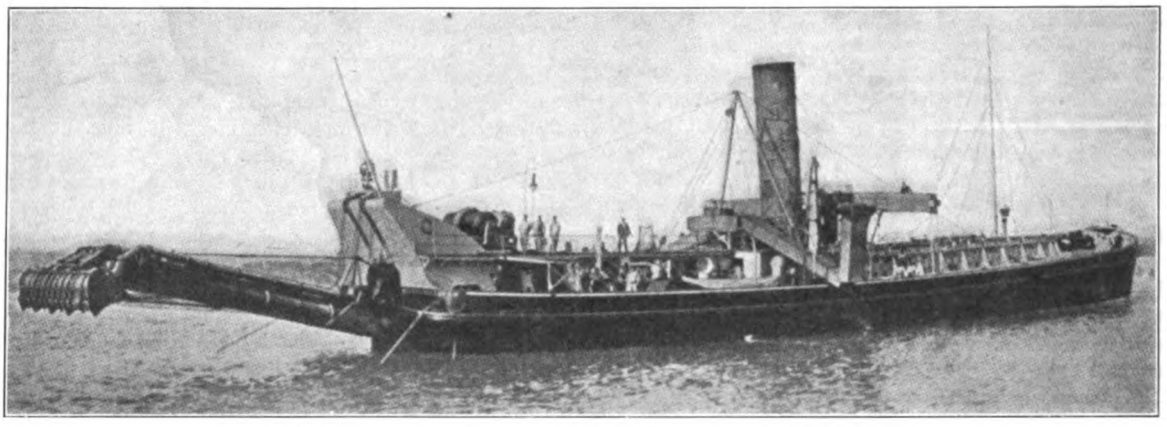


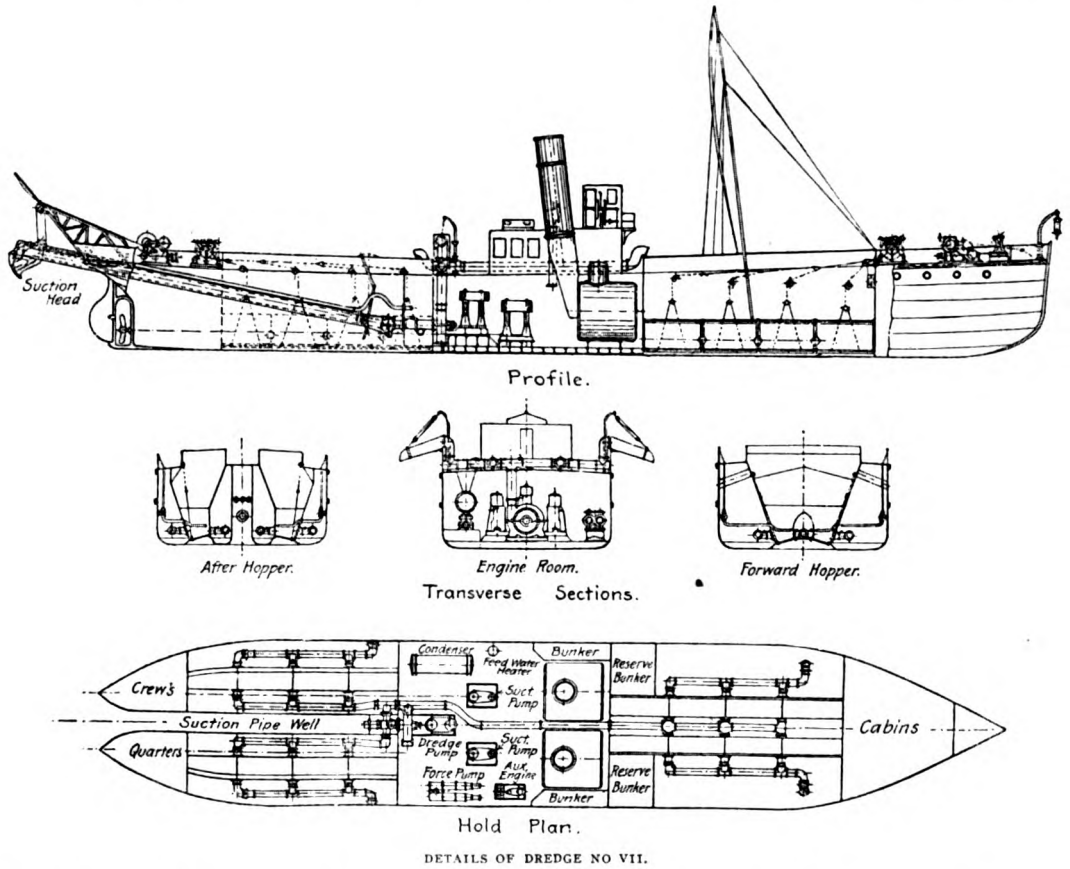
DREDGE NO. VII.

two distinct stages: first, the mechanical cutting and mixing and then the removal by suction, the suction forces acting entirely inside the head and not outside of it, as in the ordinary dredge.

In her trials *Dredge No. VII.* greatly exceeded anticipations. The contract called for a pumping capacity per hour of 4,500 cubic yards in soft ground. The actual result on trial was 6,500 cubic yards (about 7,700 tons); in heavy, sandy ground (specific gravity, 1.96) the dredge excavated 4,680 cubic yards, the proportion of solids in the discharge being 65 percent.

A secondary valuable feature of the Fruhling dredge is the method by which the hopper contents can be sucked back through the pumps and discharged on shore through a swiveling deck pipe, by means of which a temporary connection to a shore line of pipes can be made. Hitherto hopper dredges have had to dump through the bottom doors. If it is desired to use the dredgings for reclamation either a special dredge with connections to a long shore-pipe line is necessary, or with the hopper dredges it is necessary to dump alongside a stationary dredge and repump, with a consequent loss of time, material and money.

This is obviated in the Fruhling design. A suction pipe extends along the center of hopper through the hollow center girder and communicates with the interior of the hopper through lateral branches. Opposite to these branches on the hopper sides are similar branches connecting with fore and aft pipes having sea inlet connections through the ship's side. When the hopper is charged and it is desired to repump its contents, which may have packed very firmly, the sea inlet valves are opened, admitting water into the wing pipes. On opening the valves in the lateral branches and starting the suction pump, water is drawn across the openings between the branches. This rush of water carries the dredgings lying between the pipe branches, and the superincumbent masses of



DETAILS OF DREDGE NO VII.

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material gradually fall down and are sucked into the pumps. The pump discharges through a rising pipe into the swiveling deck pipe, shown in Fig. 2, by means of which temporary connection is made to a shore pipe line. It has been found that approximately the same time is taken to pump the hopper load ashore as was spent in dredging it. Further, the dredgings, as dropped from the shore-pipe end, are in the semi-fluid form, and there is no rush of excess water as with the ordinary shore-pumping methods.

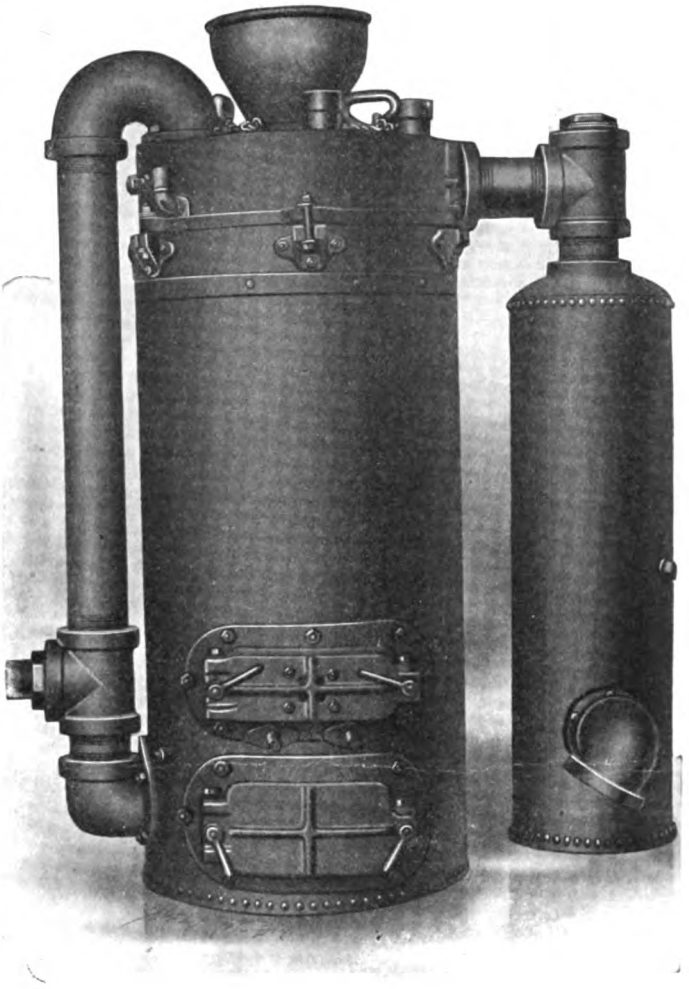
In the practical use of the Fruhling dredge several secondary advantages conduce to greater economy and efficiency. For example, the dredge normally operates at a speed of 4 to 5 knots over the ground; it is, therefore, always under good steerage way, and can avoid passing vessels and maintain a fair course against tide and wind. In addition, the action of the cutting head, free from any suction influences, is to leave the surface dredged level and clear of over-depths and side or under cuts. The ordinary suction dredges frequently leave deep pits and high ridges in the dredged channel, and their operation near dock walls or loaded wharves often involves a serious risk of undermining such work. Slipping of dock walls from this cause has actually happened.

A GAS-PROPELLED MOTOR BOAT.

About two years ago, Mr. Gray, president of the Mianus Motor Works, Mianus, Conn., designed a 25-horsepower marine gas producer for installation in a small motor boat. As compared with the ordinary gas producer used for stationary power plans, this producer effects a great saving in space, at the same time maintaining the efficiency of the stationary type. The saving of space is effected by the design of the scrubber, which is only one-quarter the size of the generator, whereas, in ordinary stationary plants, the scrubber is usually about twice as large as the generator. Salt water is used in the scrubber instead of fresh water, making the entire apparatus easily available for ocean-going travel.

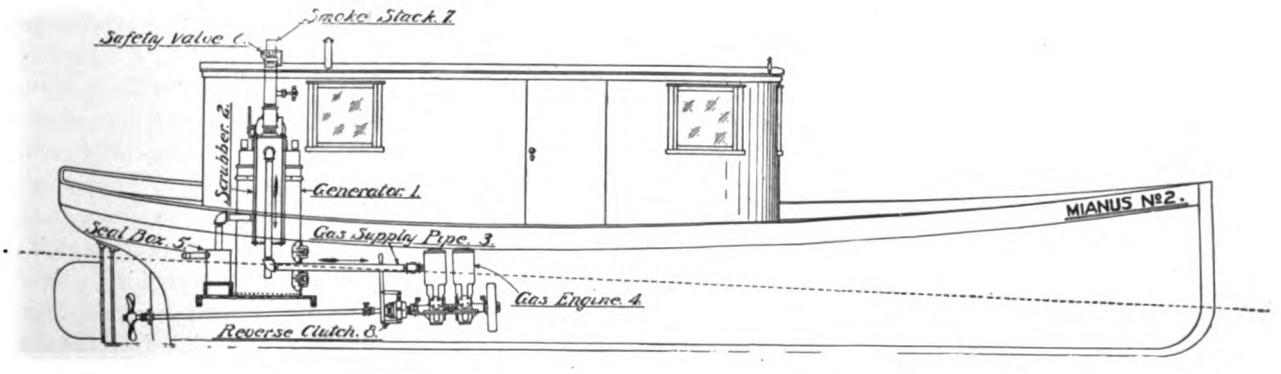
The grates in the generator are arranged to shake and dump without opening the doors. The entire plant is thus made as simple and easy to operate as possible.

The boat has been in service since July, 1908, principally on Long Island Sound. The operation of the producer has been found to be excellent in all kinds of weather, and the cost of operation, when using hard pea coal, is only about 27 percent of the cost of the same plant operating with gasoline. An average of from 1 to 1¼ pounds of coal per horsepower-hour is consumed, and, in the 25-horsepower plant, assuming a maximum of 1¼ pounds of coal per horsepower-hour, the consumption for ten hours would be 313 pounds, and with coal at $6 (£1.25) a ton, the total cost would be 94 cents (£0.19). The same size motor operating on gasoline would require 1/10 of a gallon of gasoline per horsepower-hour, or a total of 25 gallons for ten hours, making a total cost at 14 cents a gallon of $3.50 (£0.72).



GAS PRODUCER AND SCRUBBER.

The space occupied by the 25-horsepower producer is 4 feet by 6 feet; the height over all, 5 feet, and the total weight is 1,200 pounds.



GENERAL ARRANGEMENT OF MIANUS MOTOR BOAT.

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Dredges.

Although dredges form only a small part of the total tonnage of shipping produced each year, yet on account of the important part which they play in the navigation of rivers and harbors their design and construction should be carefully considered by shipbuilders and marine engineers. Like many other pieces of floating apparatus, early types of dredges were developed largely by contractors or engineers who were chiefly concerned with the work which the dredge was to perform rather than with the vessel in which the apparatus was to be installed. Consequently, early types of dredges usually consisted of some form of bucket or dipper conveniently placed on a scow with means for raising and lowering the bucket and discharging the contents into a barge. As dredging operations became more extended the apparatus naturally increased in size, although the general principles remained the same. As a matter of fact, the scow type of hull is not well adapted to dredger construction. The design of a dredge involves the placing of heavy machinery in various parts of the hull, as well as providing for the excessive strains set up in the structure due to the operation of the dredge. These strains, due primarily to the thrust of the ladder, must be provided for by a thorough system of longitudinal and athwartship bracing in the hull, and all the machinery requires secure foundations, which should form a part of the hull structure itself. These facts are best appreciated by a marine engineer, and the best results can obviously be secured when both hull and machinery are designed with a view to their relative requirements and limitations.

Sea-going bucket dredges are usually of the stern-well type, in which the dredging apparatus consists of a series of buckets operating on an endless chain through a well located on the center line of the boat, either at the bow or stern, as may be desired. The design of dredges of this type more nearly approaches ordinary steamship design, and such dredges are built of large size and great power, some of the most recent ones being over 300 feet long. The most common type of sea-going dredge, however, is the suction dredge, and the introduction of this type is undoubtedly the most important departure in design that has yet been introduced.

Until recently suction dredges have been of comparatively small size, capable of handling a few hundred tons of material an hour; nearly all operated on the same general principle—that is, a suction pipe 18 or 20 inches in diameter fitted with some form of scraper or suction head, capable of being raised or lowered, and either dragging after the vessel or projecting forward from it, is connected to a centrifugal suction pump which draws a comparatively large volume of water into the suction head and along with it a certain amount of the mud or sand which is to be raised. The contents of the pipe are then forced into the hopper of the vessel or into a barge alongside, where the mud and sand settle to the bottom of the hopper and the water is allowed to overflow. Some form of rotary cutter is usually provided in the suction head in order to break up hard or clayey substances, so that the suction forces will draw the material into the pipe.

It is obvious that this type of dredge is inefficient in operation from the fact that, with every cubic yard of material raised by the pump, a great quantity of superfluous water must also be raised only to be discharged again. Frequently, too, much of the solid material which is raised by the pump escapes with the overflow water, so that in some of the largest and most up-to-date dredges of the hopper type it has been found that oftentimes in service in certain kinds of material only about one-tenth of the power expended at the pump is actually realized in raising solid material which can be secured in the hopper. Apparently the most successful attempt to overcome this waste is found in the Fruhling system of suction dredging, where the end of the suction pipe is provided with an inverted dipper or bucket, which scrapes up the material and brings it to the suction head before the suction forces are allowed to act upon it. By means of this system it is claimed that the solid material can be

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raised without at the same time raising a large percentage of water. It is claimed that the material as it leaves the discharge pipe is a dense black or gray semi-fluid similar in consistency to mortar. In soft mud and earthy material it has been found possible to pump and secure in the hopper about 90 percent of the solid material, whereas in the former type of suction dredge 15 or 20 percent was considered highly satisfactory. Even in coarse or hard sand it has been found possible to secure 50, 60 or even 70 percent of solid material.

The remarkable development in the size of suction dredges is apparent when it is considered that the latest addition to the fleet consists of a vessel 500 feet long, capable of raising 10,000 tons of material from a depth of 70 feet below the water level in fifty minutes. Reciprocating engines direct connected to the pumps and cutter mechanism, winding machines, etc., are usually employed for power purposes. In self-propelled, seagoing dredges the main propelling engines are frequently installed so they can be disconnected from the propeller shafts and connected to the pump shafts by clutches, so that the same engines can be used for both purposes. Electricity has been used to a certain extent, but not very widely, in operating dredges. The facility of transmission and ease of control will be important factors in its successful application to this work. Chains have almost entirely disappeared from dredges, and wire rope has been substituted in their place. Wire rope not only runs more smoothly and with a great deal less noise, but also gives warning when there is a possibility of breakage, something which does not occur when chains are used.

Naval Boilers.

Not so very many years ago the British Admiralty made the costly experiment of installing in its war vessels almost exclusively a single type of watertube boiler. This was done before it had been conclusively proved that the boiler adopted possessed superior advantages over other types of boilers then in existence. The result of the experiment was that after a short period of service this type of boiler was abandoned as unsuitable for naval purposes, and, wherever it was possible to do so without entailing too great expense, other boilers were substituted for them in ships then under construction. It is doubtful if any nation will ever again give any particular type of boiler such an extensive trial as this without first making careful comparative tests. It has been the policy in nearly every case to adopt a certain type of boiler only after its advantages have been conclusively proved by comparative results with other types of boilers.

A splendid opportunity was given in the recent around-the-world cruise of the American battleship fleet to compare the results of four different types of boilers under cruising conditions. One of these types, namely, the Scotch boiler, need hardly be considered in the results, as the question of weight now practically prohibits the use of Scotch boilers in naval vessels, notwithstanding their excellent economy and durability, and it is likely that those now fitted will soon be replaced by watertube boilers. Leaving out of the question the Scotch boiler, interest centers in the relative advantages and disadvantages of using large tube and express boilers. The results of observations of the performance of the boilers made on the cruise of the American fleet, as stated by one of our correspondents elsewhere in this issue, are valuable in this connection. The figures given for economy of coal consumption are, of course, very general, as no attempt was made to analyze the efficiency of propellers, engines and boilers, and without more definite data the actual comparative efficiency of the boilers could not be stated exactly. The main point brought out by our correspondent—and, perhaps, after all, the most important point to be considered—is the question of maintenance and repairs. In general, the express type of boiler, although permitting a slight reduction in weight, is more inaccessible for general repairs than the large tube boiler; consequently, the large tube boiler can be kept in a better state of readiness for service, and while scaling, corrosion and deposits of soot, grease, etc., may not be more prevalent in the one type than in the other, yet their effects seem to be less harmful in the large tube boiler than in the express type, chiefly for the reason that the large tube boiler can be more easily cleaned and inspected, and when necessary defective parts can be readily replaced in a short time by the fire-room force. Any boiler that can be easily cleaned and repaired without the necessity of taking the ship to a navy yard possesses an advantage which for military purposes cannot be overestimated, as the boiler can then be kept in the best of condition and will always be in shape to respond to forcing. The durability of boiler casings, while not as important as the durability of the boiler itself, is also an important point in naval vessels.

The economy when steaming at full power and the ability to stand forcing are not considered in this article, since the observations were made almost wholly at cruising speeds. Small tube or express boilers naturally permit of forcing to a higher rate of evaporation per square foot of heating surface than large tube boilers; but, at the same time, this result is obtained at the sacrifice of durability and accessibility for repairs. The question of the use of a more rugged type of express boiler, or one which might be termed a semi-express boiler, capable of withstanding rough usage, and, at the same time, capable of being forced to a high rate of evaporation per square foot of heating surface, has been brought forward tentatively from time to time; but as no boilers of this type are installed on any United States battleship, there is no opportunity to make a satisfactory comparison of their performance with the other boilers.

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Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports the following percentages of completion of vessels for the United States navy:

BATTLESHIPS.

	Tons.	Knots.		Mar. 1.	Apr. 1
S. Carolina..	16,000	18½	Wm. Cramp & Sons.....	82.3	86.9
Michigan ...	16,000	18½	New York Shipbuilding Co...	93.0	95.2
Delaware ...	20,000	21	Newp't News Shipbuilding Co.	68.5	73.0
North Dakota	20,000	21	Fore River Shipbuilding Co...	74.5	77.9
Florida	20,000	20¾	Navy Yard, New York.....	4.8	8.4
Utah	20,000	20¾	New York Shipbuilding Co...	5.6	10.8

TORPEDO-BOAT DESTROYERS.

Smith	700	28	Wm. Cramp & Sons.....	67.8	71.4
Lamson	700	28	Wm. Cramp & Sons.....	66.3	69.4
Preston	700	28	New York Shipbuilding Co...	60.2	64.1
Flusser	700	28	Bath Iron Works.....	60.6	63.2
Reid	700	28	Bath Iron Works.....	60.0	63.0
Paulding ...	742	29½	Bath Iron Works.....	5.0	7.0
Drayton	742	29½	Bath Iron Works.....	5.0	7.0
Roe	742	29½	Newp't News Shipbuilding Co.	17.6	29.5
Terry	742	29½	Newp't News Shipbuilding Co.	17.1	27.4
Perkins	742	29½	Fore River Shipbuilding Co...	11.7	15.7
Sterrett	742	29½	Fore River Shipbuilding Co...	11.7	15.7
McCall	742	29½	New York Shipbuilding Co...	8.2	10.5
Burrows	742	29½	New York Shipbuilding Co...	8.1	10.0
Warrington..	742	29½	Wm. Cramp & Sons.....	8.4	12.4
Mayrant	742	29½	Wm. Cramp & Sons.....	8.1	12.2

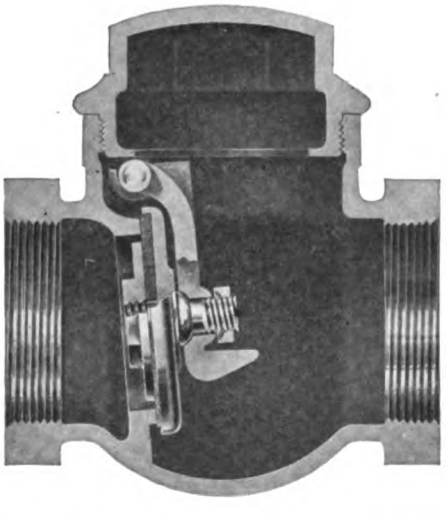
SUBMARINE TORPEDO BOATS.

Stingray	...	..	Fore River Shipbuilding Co..	77.5	82.0
Tarpon	...	..	Fore River Shipbuilding Co..	76.2	81.7
Bonita	...	..	Fore River Shipbuilding Co..	71.5	76.7
Snapper	...	..	Fore River Shipbuilding Co..	71.0	76.3
Narwhal ...	...	..	Fore River Shipbuilding Co..	74.4	84.2
Grayling ...	...	..	Fore River Shipbuilding Co..	70.7	77.8
Salmon	...	..	Fore River Shipbuilding Co..	64.2	66.6
Seal	...	..	Newp't News Shipbuilding Co.	4.6	8.8

ENGINEERING SPECIALTIES.

The Nelson Bronze Swing Check Valve.

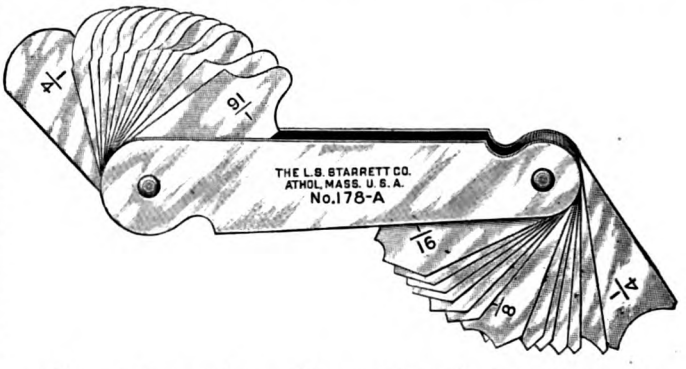
The valve illustrated is designed for working pressures up to 125 pounds per square inch, each valve being tested to 250 pounds. For steam service this valve has a bronze disc fastened to a self-hinging clapper. When used for hydraulic work, the valve has a leather disc, kept in place by means of a bronze disc retainer. The body is cast in one piece and



the bearing for the clapper is cast in the valve body. The ball and socket joint between the disc and the clapper provides free movement, so that the back pressure causes the valve to seat perfectly. When the valve is open the flow is unrestricted to the full capacity of the line. The valves are manufactured by the Nelson Valve Company, Wyndmoor, Philadelphia, Pa., in sizes suitable for use on pipes ranging from ⅜ to 3 inches in diameter.

A Fillet or Radius Gage.

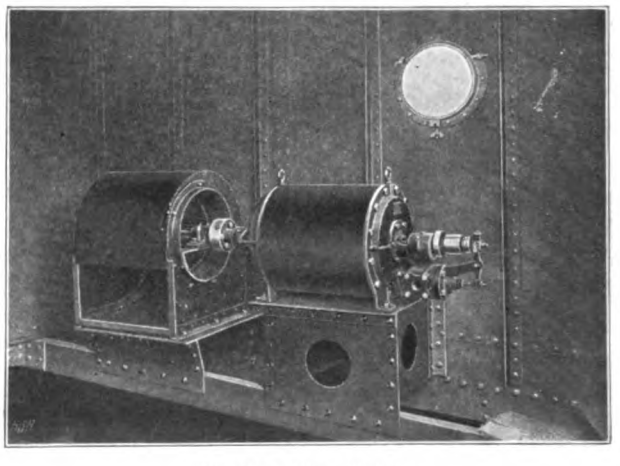
This gage, which is manufactured by the L. S. Starrett Company, Athol, Mass., is also referred to as a concave and convex gage and is especially adapted for use in laying out special forming tools, dies, etc., as well as for measuring fillets, making the tool of use to machinists and tool makers, as



well as pattern makers. The gage is made in two sizes, one with 26 leaves stamped to indicate radii by sixty-fourths from 1/16 inch to ¼ inch, and one with 32 leaves stamped to indicate radii by sixty-fourths from 17/64 inch to ½ inch. The illustrations show a few of the ways in which the gage may be used to advantage.

Sirocco Fans.

The distinguishing features of the Sirocco fan, manufactured by the American Blower Company, Detroit, Mich., are found in its blast wheel or runner. This is of drum form, with a large inlet chamber inclosed by numerous blades, which are very long axially but narrow and are curved forward. Instead of having from eight to sixteen blades it usually has sixty-four, and these blades are generally from six to nine



TURBINE-CONNECTED FAN.

times as long as they are wide. This type of construction permits a given sized wheel at equal speeds to discharge a volume of air about four times as great as the old type of steel plate fan, or for a given duty it is claimed that the Sirocco fan can be made about one-half the diameter of the former standard paddle-wheel. By comparison with the former type the Sirocco fan occupies about one-half the space, saves one-third the weight and about one-fifth of the power. These advantages are very important when the fan is applied to marine work, but by no means the least important advantage is the fact that the fan does its work with very little noise, adding greatly to the comfort of passengers on board ship. The fans are made with either single-inlet runners or double-inlet runners, and may be driven by direct-connected reciprocating en-

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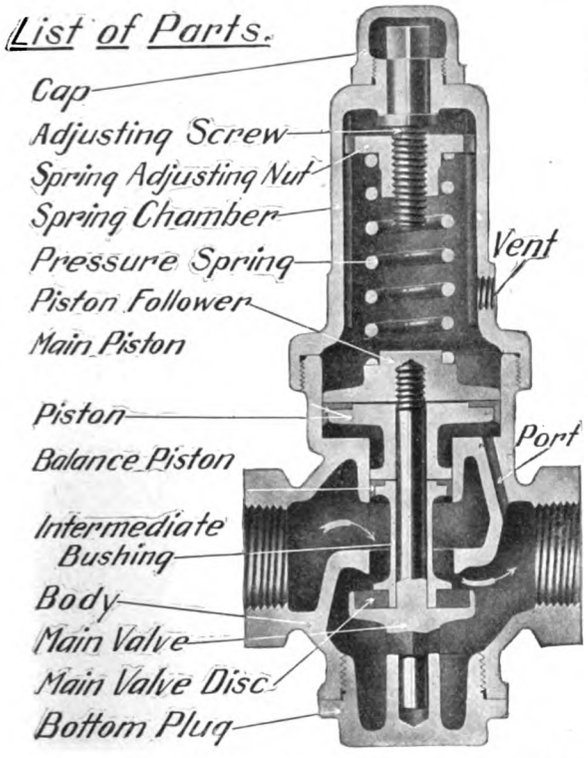
gines, electric motors or steam turbines. The increasing use of small steam turbines for driving the auxiliaries on board ship makes this type of installation perhaps of most interest. The illustration shows a 20-inch double-inlet fan, direct connected to a steam turbine for forced draft installation. The blower has a capacity of 28,000 cubic feet against a pressure of 5½ inches of water at 1,500 revolutions per minute. Forty-brake horsepower are required to drive the fan and an efficiency of 65 percent is claimed.

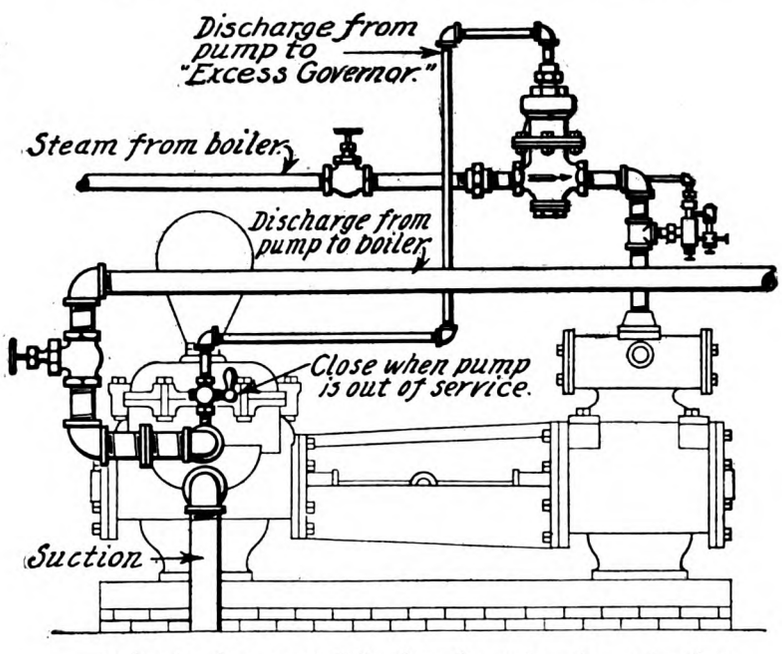
An Improved Method of Governing Pumps.

Most pump governors are designed to maintain the water discharge pressure at a certain fixed point, but there are numerous conditions under which this uniform discharge pressure is not altogether desirable—as in feeding boilers where the boiler pressure may vary. The disadvantage of a uniform high-feed pressure is readily evident on marine boilers where, say, 250 pounds pressure is carried at sea and perhaps only



80 pounds while in port. In these instances, unless the governors were frequently readjusted, pumps equipped with ordinary governors, would at all times tend to keep the feed-line pressure over 250 pounds. The enormous surplus pressure on the feed line when the boilers were running on the lower pressures would tend to throw the feed water into the boiler with great force, would grind out the valves quicker, would make accurate feeding difficult, and the pumps would race whenever the feed valves were opened. The fireman or water tender must also manipulate the throttle valve oftener, if there were no feed-water controllers on the boilers. It would thus be difficult to maintain the correct water-level in the boilers and, in addition to being noisy, the pumps would wear unduly. In cases like this it would be highly desirable if the governor maintained the feed-line pressure at just the right excess at all times to make the flow into the boiler regular.

The Foster excess pump governor, manufactured by the Foster Engineering Company, Newark, N. J., automatically maintains a fixed excess discharge pressure above the boiler pressure regardless of the amount of water being supplied. Referring to the cross section, it will be seen that the governor is provided with two diaphragms, the upper one subjected to the pump discharge pressure through the connection at the top of the governor, while the lower diaphragm is in communication with the boiler pressure. Between these two diaphragms is a differential washer, the proportions of which determine the excess of water pressure over the boiler pressure. Reducing the area of the upper surface of this differential washer will increase the excess discharge pressure and vice versa. Steam entering the valve passes through the port to the boiler under the lower diaphragm. This tends to raise the diaphragm and allow the upper spring to lift the auxiliary valve off its seat and permit steam to enter the piston chamber, thus forcing down the piston and main valve with which it is engaged and allowing more steam to pass to the pump. When the pump discharge pressure passing through the connection in the top of the governor reaches its proportional excess it acts on the upper diaphragm, forcing it down and tending to close the auxiliary valve. The steam pressure on top of the piston is thereby reduced, permitting the lower


Discharge from pump to "Excess Governor."
Steam from boiler.
Discharge from pump to boiler.
Close when pump is out of service.
Suction

spring to close or partially close the main valve and reduce the steam pressure to the pump. The operation is not intermittent but continuous, the pump automatically slowing down or speeding up as conditions require.

TECHNICAL PUBLICATIONS

Oil Motors. By G. Lieckfield. Size, 6¼ by 8¾ inches. Pages, 272. Figures, 306. London, 1908: Charles Griffin & Company, Ltd. Price, 15s. net ($4.50).

This book is a translation of the third edition of *Die Petroleum und Benzinmotorem*, which in Germany constitutes a handbook widely read by all persons interested in the construction or operation of stationary and automobile engines using liquid fuel. From a description of the liquid fuels available the author leads up to the construction of various types of engines with explanations of their various parts, the functions of the latter, and concludes with very complete notes on troubles which may occur with gas engines and the various means of rectifying them. A number of pages are devoted to a discussion of marine engines and recent motor boats, showing installations as large as 3,000 horsepower.

Since the same appellations are not used for oil fuels in different countries, it is necessary for the reader to note carefully how various oils are designated. In this book the

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report of the fuels committee of the Motor Union of Great Britain and Ireland have been very closely followed, in the hope that by adopting recognized standards the meaning of the various appellations will be accurately interpreted.

Regarding the much disputed question of what petroleum really is the author sustains the theory that it is the result of a natural distillation of animal matter. The most that can be said in favor of this theory is that it is quite as justifiable as the theories which class petroleum as the result of decomposition of vegetable remains or as the result of natural reaction of gases upon minerals.

The Economy Factor in Steam Power Plants. By George W. Hawkins. Size, 6 by 9 inches. Pages, 133. Figures, 49. New York, 1908: Hill Publishing Company. Price, $2.

The problems of power plant efficiency and economy are among the most important which must be met by the engineering profession. The possibility of a future scarcity of fuel and the certainty of increasing fuel costs lend additional weight to the subject. Moreover, the subject is one on which too often the designer is placed upon his own resources, so that he can obtain little information outside of what he has collected during his own experience as an engineer. In fact, there has been a tendency for individual members of the profession to jealously guard such information as part of their most valuable assets. Perhaps this feeling accounts for the fact that up to the present time little has been published treating comprehensively of this subject. The data used in compiling the work under review have been carefully selected from the results of actual experiments, all unauthentic reports and manufacturers' claims being absolutely discarded. One can be reasonably certain, therefore, that he has before him an authentic collection of data upon the economic performance of various pieces of apparatus which are used in a marine steam power plant.

The book is divided into four parts, the first taking up individual apparatus, such as boilers, engines, electrical generators, condensing apparatus, feed pumps, oil pumps, oil burners, feed-water heaters and fuel economizers. Part II. discusses the factor of evaporation, showing its effect upon complete plant economy and also the influence of the various auxiliaries upon it. In Parts III. and IV. the complete plant economy is considered, the full rated load being taken up in Part III. and the variable load in Part IV. Although it was the original intention to make the work apply only to oil-burning plants, yet the necessary conversion charts have been added, so that the results may be readily converted from oil to coal or wood, as desired. The part of the book relating to boiler efficiencies refers primarily to oil-burning practice.

The Gas Engine. By Forrest R. Jones. Size, 6 by 9 inches. Pages, 447. Figures, 142. New York, 1909: John Wiley & Sons. Price, $4.

The general order in which the subject is treated in this book is descriptive, operative, testing for faults, theoretical and results of trials. The descriptive portion is particularly well illustrated, many details being given which usually are shown only in the assembled engine. In connection with the operation of gas engines, illustrations are given of actual plants, and especial features of each are given in detail, showing not only the methods of starting and cooling, but also the method of regulating or governing the speed of the engine.

The part of the book describing tests is thoroughly practical, and will be of particular interest to operating engineers who may not have the advantage of theoretical training. Numerous examples of indicator cards, taken in actual practice, are given, and the calculations for finding horsepower are shown in detail. Considerable space is devoted to a description of producer gas apparatus and the fuels which are used for gas making. In this connection economy and efficiency are carefully considered.

The last part of the book is taken up with the theoretical discussion of various heat cycles and pressure-volume diagrams, while the results of the more important tests made by the United States Geological Survey are tabulated, showing the approximate analysis of various coals, the composition of producer gases from various fuels, and finally the number of pounds of coal per brake-horsepower delivered by the engine.

General Lectures on Electrical Engineering. By Charles Proteus Steinmetz, A. M., Ph. D. Size, 6 by 9 inches. Pages, 284. Figures, 48. Schenectady, N. Y., 1908: Robson & Adee. Price, $2.

These lectures, seventeen in number, are general in nature, dealing with the problems of generation, control, transmission, distribution and utilization of electric energy; that is, with the operation of electric systems, of apparatus under normal and abnormal conditions, and with the design of such systems, although the design of apparatus is discussed only so far as necessary to explain its operation and so judge of the proper field for its application. Due to the limitations of time and space, the treatment of such involved subjects must necessarily be essentially descriptive and not mathematical. That is, it comprises a discussion of the different methods of application of electric energy, the means and apparatus available, the different methods of carrying out the purpose and the relative advantages and disadvantages of the different methods and apparatus which determine their choice.

COMMUNICATION.

The Fastest Ships in the World.

Editor International Marine Engineering:

Supplementing your interesting article on the fastest ships (February, 1909) I should like to point out the extremely high value of $\frac{V}{\sqrt{L}}$ for motor boats. I have no reliable figures but I believe the following are fairly accurate:

	Length.	K. Speed.	$\frac{V}{\sqrt{L}}$
Hutton II	39′ 9″	21.5	3.4
Legro-Hotchkiss	39′ 3″	29.6	4.73
Napier II	40′ 0″	25.0	3.95
Napier I	39′ 9″	18.8	2.98
Quicksilver	30′ 0″	18.2	3.32
Takumono	21′ 4″	12.8	2.77
Britannia III	55′ 0″	13.0	1.75
Wolseley-Siddeley	39′ 4″	30.4	4.85
Wolseley-Siddeley*	39′ 4″	27.35	4.43
Dixie II*	39′ 6″	31.347	4.94
Dixie II	39′ 6″	27.75	4.41
C. G. Patrol	75′ 0″	12.5	1.44
Dragonfly	40′ 0″	18.0	2.85
Oriole	40′ 0″	21.2	3.35
Irene	39′ 8½″	25.725	4.08

* In race.

It will be seen that, in calm water, these boats are very fast relative to their length. E. M. Dixon.

The type of ferry described on page 29 of our January issue, which is in use at Finnieston in Glasgow harbor, was invented, patented and first constructed by William Simons & Company, Renfrew, for this particular service. The first boat of this type to be constructed was the *Finnieston*, 80 feet long, 43 feet beam, 9½ feet full-load draft. She was built by Messrs. Simons & Company in 1890, and has proved so valuable for this service that the additional boat described in our January issue has recently been built by Ferguson Bros., Port-Glasgow, for the same service.

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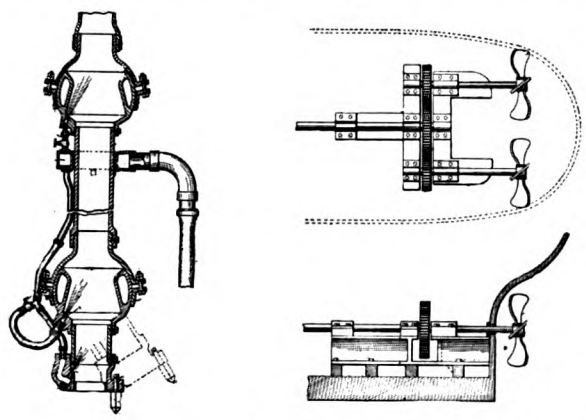
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., registered patent atorney, Loan & Trust Building, Washington, D. C.

910,277. APPARATUS FOR ELEVATING GOLD-BEARING DEPOSITS FROM RIVER BEDS. ALBERT LEE ELIEL, OF SAN FRANCISCO, CAL., AND OSCAR H. ELIEL, OF LA SALLE, ILL., ASSIGNORS OF ONE-THIRD TO LEWIS E. AUBURY, OF SAN FRANCISCO.

Claim 4.—An open-ended, vertically-arranged, hollow shaft, an air box mounted on the hollow shaft at the upper end, air tubes communi-



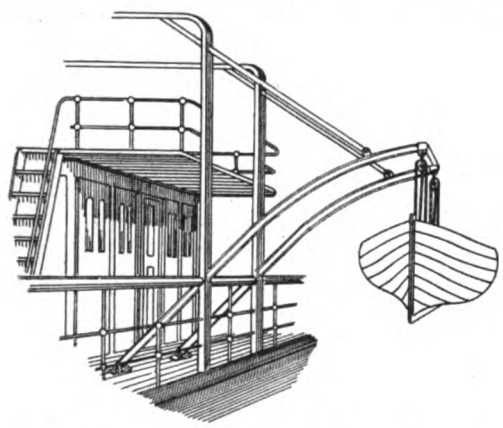
cating with the air box and with the lower end of the hollow shaft and a flexible tube communicating with the air box and with a source of compressed air. Twenty-seven claims.

910,489. WAVE POWER. LEWIS WOLFLEY, OF PRESCOTT,

Claim 3.—In a wave power, the combination with piers arranged to provide inlets therebetween, of a float reciprocally mounted within an inlet, an anchor beam extending across said inlet and sliding in channels in said piers, guides upon said float engaging said anchor beam, guide rods slidingly connecting said float and anchor beam and preventing lateral movement of the former, and power-transmitting devices operated by said float. Seventeen claims.

910,594. APPARATUS FOR LOWERING SHIPS' BOATS. CHRISTEN SMITH, OF SLEMDAL, NEAR CHRISTIANIA, NORWAY.

Abstract.—The boat rests on chocks which can be quickly removed by means of a system of tackles or similar appliances; the boat then hangs freely in a frame-like contrivance which is capable of turning in a vertical plane on pivots placed considerably lower than the boat and in-



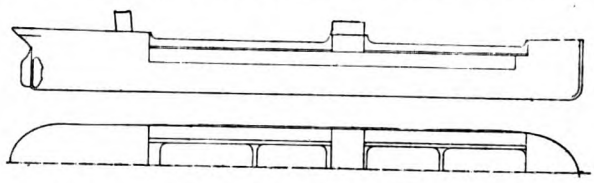
side its point of suspension. This suspension frame is kept in position by a system of tackles controlled from the boat, and these tackles have only to be eased off in order that the boat may be brought away from the side of the vessel ready to be lowered into the water. To the suspension frame are attached bars whose other ends are arranged to be movable in a transverse direction, being at the same time connected with ratchet and pawl arrangements to prevent any inward movement. By this means the rolling of the ship will not cause the suspension frame to turn inwardly while being lowered. One claim.

912,198. PROPELLING MECHANISM FOR BOATS. JAMES T. STAFFORD, OF NEW YORK, N. Y.

Claim.—A boat comprising a T-shaped structure consisting of a transversely disposed member and a forwardly extending longitudinally disposed member, a U-shaped structure consisting of a transversely disposed member and rearwardly extending longitudinally disposed members, bearings secured to the transversely disposed member of the T-shaped structure and to the longitudinally disposed members of the U-shaped structure, shafts journaled in the bearings, propeller wheels secured to the shafts, pinions secured to the shafts and disposed between the transversely disposed members of the structure, bearings secured to the transversely disposed members of the structure and to the longitudinally disposed members of the T-shaped structure, a shaft journaled in the bearings and a pinion mounted on the shaft and meshing with the first-named pinions, said last-named pinion being also arranged between the transversely disposed members of the structure. One claim.

911,581. CARGO VESSEL. JOHN ROBERT FROST DETTMER, OF SUNDERLAND, ENGLAND.

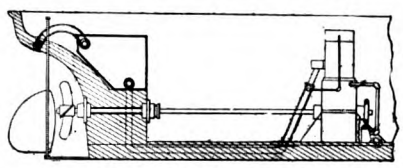
Claim.—In ships the combination of a hull, tanks of uniform section throughout disposed thereon continuously from the poop to the after end of the forecastle, top plates to said tanks carried inwardly to meet



the shell plating of the vessel below the joints between said plating and the hatchway coaming, and outer sides to said tanks which are set back from alinement with the sides of the vessel. One claim.

911,670. ENGINE. WILLIAM H. McLEOD, OF BOSTON, MASS.

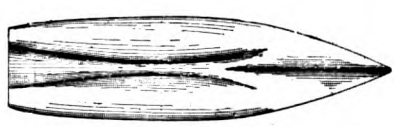
Claim 1.—A launch, having, in combination, a hydro-carbon motor, a



well communicating with the water outside of the launch, and an exhaust pipe for the motor passing through the well. Four claims.

911,806. BOAT. NAPOLEON B. BROWARD, OF TALLAHASSEE, FLA.

Claim.—A water craft, the bottom of which is formed of two rounded symmetrical and parallel after parts forming an intermediate channel, and a single forward part, the two after parts at the bottom partially



lapping upon the single forward part, but at a distance laterally therefrom, with channels between the overlapping parts formed by the shape of the bottom itself, and leading from the sides of the bow to the central channel. One claim.

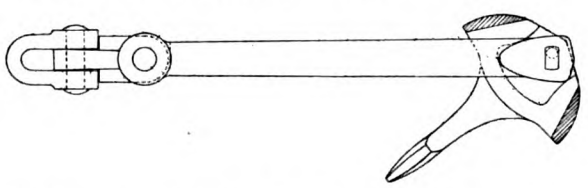
912,814. HYDROPLANE VESSEL. GEORGE RONSTROM CLIFFORD, OF CHICAGO, ILL.

Claim 1.—A hydroplane vessel, the entire bottom of which inclines backwardly and downwardly and forms the hydroplane, having a

pointed prow, a transversely rounded hull and a rearward, vertically tapering main body extension of considerable length, extending below the water line, the undersurface of which extension forms a continuation of the vessel's bottom. Six claims.

913,367. ANCHOR. THOMAS DOWNIE, OF LIVERPOOL, ENGLAND.

Claim 1.—In ships' anchors, a head having a passage therethrough and chambers in the side walls of the passage, the front walls of said chambers being curved, a shank provided with projections relatively



smaller than the said chambers, and so shaped that the opposite edges of each projection engage with the corresponding edges of each chamber when the shank is in its extreme positions, and the front edge of each projection bears against the curved front edge of each chamber. Two claims.

913,787. SUBMERGED FEATHERING PADDLE-WHEEL. LADISLAV VOJACEK, OF PRAGUE, AUSTRIA-HUNGARY.

Claim 2.—The combination of a stationary casing, a rotary inclosed casing arranged below the stationary casing, a hollow shaft penetrating the stationary casing and carrying the rotary casing, bevel gearing, inclosed in the stationary casing, for rotating said shaft and the rotary casing, a plurality of blades or paddles journaled in the rotary casing, a central gear inclosed by the rotary casing, other gears inclosed by said rotary casing and connecting the blades or paddles with the central gear, a shaft carrying said central gear and penetrating the hollow shaft and means for rotating said last-named shaft. Four claims.

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British patents compiled by Edwards & Co., chartered patent agents and engineers, Chancery Lane Station Chambers, London, W. C.

20,672. TORPEDO ENGINES. WHITEHEAD TORPEDO WORKS AND E. LEES, WEYMOUTH.

In multicylinder torpedo engines of the single-acting, enclosed type the working parts are kept cool and free from deposit by directing the exhaust through water-cooled passages outside the crank chamber, and then delivering it to the hollow tail shaft at the rear side of a valved partition therein. In the four-cylinder engine shown, the exhaust from one pair of adjacent cylinders passes from the valve chambers, along corresponding pipes leading to a common conduit on the outside of the crank chamber. The first conduit leads to a second conduit communicating by peripheral holes with the hollow tail shaft on the side of the partition remote from the crank chamber. The water jacketing of the passages is in this case effected by allowing the sea water free access to the exterior of the crank casing. If found desirable, these passages may be formed by separate pipes instead of being integral with the crank and tail shaft casings. A valve in the partition automatically relieves any excess pressure in the crank casing due to leakage of fluid past the pistons.

21,122. TORPEDOES. G. F. JAUBERT, PARIS.

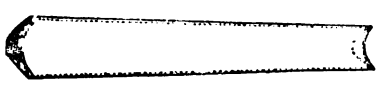
A heating device for the compressed air of torpedo engines consists of a number of cartridges with metallic or refractory envelopes and with tubular passages placed within a casing through which the air is arranged to pass. There may be insulating packing. The cartridges contain chemical fuels, and are fired simultaneously by means of a striker released by the same means which release the operating lever for the compressed air. The products of combustion do not mix with the air. The prior use is admitted of liquid-fuel burners, of incandescent thermite in contact with the current of air, and of a combustible material within tubes around which carbonic acid gas for actuating the engine passes.

21,195. SHIPS' HULLS. C. A. MANKER, PEARL, ILL., U. S. A.

The under surface is of greatest width at the point of first contact with the water, and then curves upwardly towards the bow, the submerged portion inclining rearwardly and inwardly towards the stern. Stability guards are provided, but are carried round the stern to form a counter, which becomes slightly submerged when the vessel is under way, due to the lifting of the bow, consequent upon the under-water form of the vessel.

21,649. TURBINES. J. S. GREEN, PITTSBURG, PA., U. S. A.

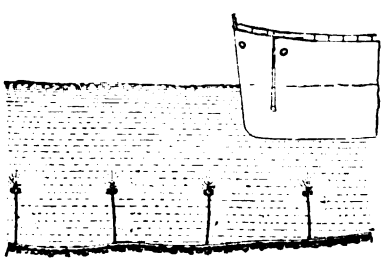
Vanes and guide-blades of elastic-fluid turbines are made with a core of stiff, resilient metal, such as steel, and are covered with an envelope of non-corrodible metal, such as copper. The envelope is attached to the



core by welding. The method preferably employed is to weld an envelope to a mild steel or iron ingot. The whole is then worked as an integral mass, and is eventually drawn into strips of the desired blade section and cut into proper lengths.

21,723. MARINE SIGNALS. L. DION, WILKESBARRE, PA., U. S. A.

A channel or ships' course is marked out at night-time and in foggy weather by a number of submerged incandescent electric lamps provided with reflectors for producing strongly illuminated patches of water, which may be close enough together to form a continuous bright track. Each lamp is buoyed at the end of a branch cable by a float, which may be constructed with the upper surface formed as a concave reflector. The bulbs of the lamps may be made thicker than usual and may be protected by cages. Different courses, such as the outward and return courses of a ferry, may be indicated by different-colored lights, and the light may be made intermittent by having an interrupter in circuit, or by switching the current alternately into two cables. In foggy



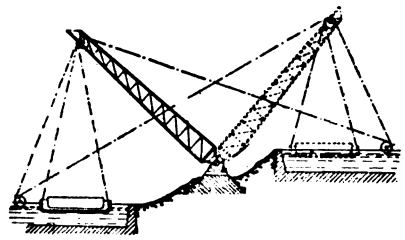
weather the lights may be observed through a water telescope or through a submerged bull's-eye in the ship's bows. The invention is specially applicable in the navigation of submarine vessels, and in time of war for indicating to friendly vessels by means of a series of lights a safe course of entry into a harbor defended by mines, the location of the neighboring mines being indicated by lights of different color, and the current being switched off as soon as the vessel is past the danger zone. The invention is also applicable for indicating the position of sunken rocks or shoals.

21,884. SCREW PROPELLERS. J. C. WALKER, GLAMORGANSHIRE.

Relates to screw propellers of the type in which the blades are secured to a circumferential ring provided with intermediate blades extending inwards, and consists in making the outer blades of an area equal to the area of the main blades less their ineffective root portion. The outer blades are at least half the length of the inner blades. The inner blades are preferably made to extend aft away from the boss, and the outer blades are arranged to extend forward from the surrounding ring. The nut by which the propeller is secured to the shaft is provided with blades.

21,731. SHIP LIFTS. B. SALOMON, FRANKFORT-ON-THE-MAIN, GERMANY.

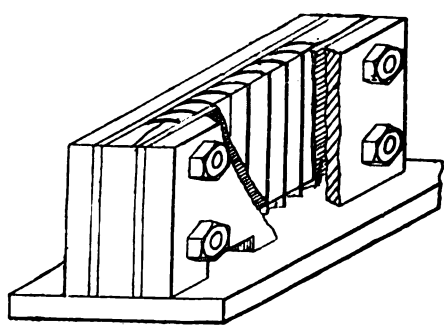
In a canal ship lift, the lifting apparatus is constructed with a member or members capable of being swung about an horizontal axis and held in position by pulling ropes or chains extending on both sides of the axis and passing over drums. The carrier is attached by ropes directly



to the members, or to a lifting appliance mounted either on the members or in the vicinity of the axis by which the carrier can be raised and lowered independently of the movement of the member. In a modification, similar to a shear, the ropes are replaced by a rigid tension or compression member having a lower bearing capable of horizontal movement.

21,756. TURBINES. W. McKELVEY, J. McKELVEY AND R. KING, BELFAST, IRELAND.

A number of blades are combined with a segmental base-block for insertion in a rotor or stator groove, by arranging them in a mold and running in molten brass or other metal round the ends. The blades are notched at the end or are perforated to increase the strength. Other forms of notch may be used, or the blades may be cut and deformed at the ends. The figure shows the metal molding box or chill in which the base-blocks are cast upon the ends. It consists of a base, side plates and end pieces secured together, a gate being left for the introduction of the metal. The blades are separated by distance pieces, and a screw is fitted at one end to tighten them up in the mold. To allow



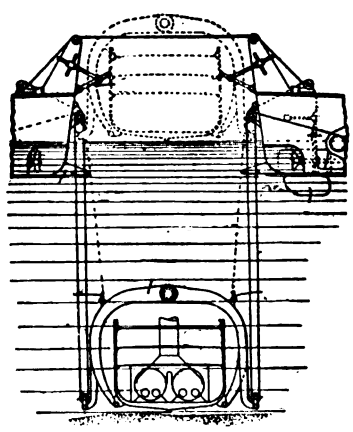
for the extra width of the base over the blades, plates of depth equal to the depth of the distance pieces are inserted, or the side plates may be stepped at the bottom. The segment is bent to the curvature of the rotor or casing and caulked into a dovetailed rotor or casing groove. The segments are locked together by a dovetailed joint or by some equivalent arrangement. The curvature may be imparted during the formation of the segment, and to facilitate insertion in the grooves a portion of one side of each groove may be removed, the last segment to be inserted being provided with a projection corresponding to the missing portion. The last segment is secured in place by screws or other means.

21,959. STEAM PUMPS. J. HUTCHINGS, LONDON.

A portable direct double-acting pump, for use in mines, ships, etc., is provided with an oscillating plug valve which controls the motive fluid to the power cylinder and the suction and discharge of the pump cylinder. The valve is provided with U-shaped divisional walls connecting the solid parts. On the completion of the stroke, the valve is oscillated by levers actuated by a tappet rod, which is connected to the piston-rod.

22,287. RAISING SUNKEN SHIPS. G. PINO, GENOA, ITALY.

In apparatus for raising submerged vessels, pairs of bowed gripping levers having clutch blocks to hold the vessel and lower tackle blocks attached at the alternate ends, are kept open during lowering by ropes



attached at intermediate points on the levers. The weight of the levers is partly balanced by cork, etc., filling. The lifting lines pass between adjustable guides; supports and ropes assist in holding the vessel when raised. The pontoons have rudders, which can be raised if required.

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